DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES,

VOL. I.

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PREFACE.

Geological Surveyor-in-Charge to the Under Secretary for Mines.

Geological Survey Branch,
Department of Mines, 7 January, 1889.

Sir,

The Geological Survey staff and other officers of the Department of Mines occasionally make discoveries and observations regarding the geology, palæontology, and mineral resources of the Colony, which, being of scientific and general public interest, it is desirable to publish.

Such information includes reports upon the geological features of certain districts. The occurrence of the rocks, minerals, and fossils represented in the collections in the Mining and Geological Museum, and notes of special laboratory work; reference to the maps and other publications of the Department will also be given. It is proposed to issue this, as far as practicable, quarterly, in a series of Parts entitled "Records of the Geological Survey of New South Wales"; and it is hoped that this publication will be a means not only of stimulating research by private persons who may have the opportunity for carrying on geological investigations, but, by circulation amongst foreign mining and scientific institutions, may make more widely known the rich natural resources of New South Wales.

I have, &c.,

C. S. WILKINSON,

Geological Surveyor-in-Charge.

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. 1.] 1889. [Part 1.

I.—Notes on the Geology of the Barrier Ranges District, and the Mount Browne and Mount Poole Gold-fields: by C. S. Wilkinson, F.G.S., Geological Surveyor-in-Charge.

In the Albert District, which comprises the north-western portion of the New South Wales territory beyond the Darling River, there are three areas of Palæozoic formations (chiefly Metamorphic Silurian slates, granite, and Devonian strata) occurring in the midst of a wide extent of the Cretaceous and Post-Tertiary formations.

The larger of these areas, about 4,000 square miles, includes the Barrier Ranges, with the far-famed Broken Hill and surrounding silver-mining district, and the Poolamacca or Euriowie Tin Mines, &c. The two smaller are gold-mining areas—one situated near the town of Milparinka, 230 miles north from Silverton, or 180 miles north-west from Wilcannia, embraces the Mount Browne Range, 22 square miles in extent; and the other, commencing a few miles further to the north, the Whittabreena Ranges and "Granite" or Tibooburra Diggings, occupies an area of about 109 square miles.

The Barrier Ranges District as far north as Corona has already been partly described by me in the Annual Report of the Department of Mines for 1884,* and in a separate report upon its mining prospects, published by the Department in August, 1884†; also the northern portion of the Albert Gold-field has been examined by Mr. H. Y. L. Brown, Geological Surveyor (now Government Geologist of South Australia), whose report, in which special reference is made to the existence of artesian water, was published in 1881.‡ The following notes were made by myself

* Page 146.

† Report on the Silver-bearing Lodes of the Barrier Ranges, in the Albert Ranges, &c., p. 12, and sketch (fcap., Sydney, 1884). Government Printer.

‡ Report upon the Albert Gold-fields, &c., especially with reference to the existence of Artesian Water, &c., p. 9, three sheets of sections, and plan (fcap., Sydney, 1881). Government Printer.

when, in 1887, I visited this gold-field with Mr. Harrie Wood, Under Secretary for Mines, and Mr. W. H. J. Slee, Inspector of Mines, as members of the Prospecting Board.

This great metalliferous area, in which silver, lead, gold, tin, copper, bismuth, manganese, iron, &c., have already been discovered, consists chiefly of ranges of Silurian, granite, and Devonian formations, bounded on the west, north, and north-east by the Cretaceous formation with Post-Tertiary clays and drifts overlying the line of junction here and there. The boundary between the Palæozoic and Mesozoic formations commences close to Thackaringa, and near where the railway from Adelaide to Silverton and Broken Hill crosses the New South Wales and South Australian border, and runs in a north north-east direction, passing three miles west of Silverton and west of Corona; thence in an irregular curving line to the north and north-east, past Packsaddle Station, to the northern end of the Kooningberry Range, near Wonaminta; thence in a similar curving course south-easterly to near Mount Murchison, north of Wilcannia on the Darling River.

In places within this area occur open plains formed of Pleistocene or Post-Tertiary deposits; sand ridges of wind-blown origin are sometimes met with. The effects of denudation by wind action are very marked in this district. The surface in many localities is covered with pebbles of quartz, and of other rocks which were once embedded in the Pleistocene sandy clays; but by the force of the wind the sand and clay have been swept away, the pebbles which the wind could not remove remaining. I have often observed the exposed surfaces of projecting rocks in a highly polished state from the friction of the sand drifted against them by the wind.

The immense beds of cream-coloured limestone, which at Corona Station are about four hundred yards wide, and extend nearly north and south for at least twenty miles, consist of magnesian limestone, or dolomite. A sample of it collected by me gave the following analysis made in the Laboratory of the Department :—

Carbonate of Lime	53·05
Carbonate of Magnesia	42·03
Insoluble in acids (sand)	3·72
Oxide of iron, with traces of Alumina	1·38
	100·18

Much of it is a good building stone, but not well suited for lime-burning for agricultural purposes.

This is the first known occurrence in New South Wales of massive beds of magnesian limestone. I could not detect any fossils in them whereby their age might be known; and owing to the numerous intrusions of granite, and the extreme metamorphism that the sedimentary rocks have in places undergone in the Barrier

District, the geological horizon of these limestones will be difficult to determine without further close examination, but they appear to be associated with the lowest beds of Palæozoic rocks of the district, and are probably of Silurian age, or older.

About eighteen miles north of Corona Station (Mr. Harvey Patterson's) we pass from the Silurian schists on to the Cretaceous formation. The latter probably extends to the north under the flat sandy country in which Lake Bencannya is situated. Then the country is in places very sandy to Packsaddle Station, where the altered Silurian schists with quartz reefs of a promising metalliferous character appear again and form low rocky hills for seven miles further north.

The large extent of gently undulating country lying between here and the Mount Browne Slate Range consists of the Cretaceous strata, overlaid in places by Pleistocene alluvial deposits, and belts of recently formed wind-blown sand ridges, which rise to a height of from twenty to fifty feet above the general level of the country. Lake Cobham, which a few years ago was quite dry, at the time of our visit presented a fine sheet of water owing to the late rains, receives the drainage of this wide-spread, nearly flat country. It occurs about three hundred and sixty feet above the sea level, and occupies a large shallow hollow or depression into which runs the Evelyn Creek, draining the country beyond Mount Browne and Mount Poole. Having no outlet, its water, as it diminishes by evaporation, becomes brackish. When Lake Yantara, to the north-east, loses its water by evaporation in dry seasons, it is said that the salt which remains crystallized upon the surface is collected for use at some of the squatters' stations.

In the wells sunk in the Pleistocene alluvial deposits, and in the upper strata of the Cretaceous, the water obtained is nearly always brackish. There is, however, no doubt that by boring or sinking to a sufficient depth in the Cretaceous formation an unlimited supply of artesian water would be met with. There is abundance of earthy gypsum, locally called "Copi," present in patches over this country.

The township of Milparinka is situated about four miles east of the north end of the Mount Brown Range and on the Evelyn Creek, where there is one of the few permanent waterholes in the district. The hole has been formed by a stratum of sandstone lying across the lower end of it. This is a good site for the construction of an overshot concrete dam, which would afford the means of conserving a splendid supply of water. A well has been sunk on the north side of the town, and a little brackish water struck, which rose in the shaft to within sixty feet from the surface. If this were deepened by sinking or boring, I believe that fresh water that would rise to the surface would be obtained. The formation is Cretaceous, and in the town several small quarries have been opened in nearly horizontal beds of sandstone grit from one to five feet thick, showing current-bedding (which dips W. 10° N. at from 25° to 35°), and vertical joints striking W. 40° S. and E. 20° S. The sandstone forms good building stone, and has been used for the court-house and other buildings;

it contains obscure impressions of plant stems. Beneath one bed of sandstone is a stratum of conglomerate containing pebbles of quartz and altered sandstone, some of the pebbles being more than one foot in diameter.

The surface of the Cretaceous country is almost level, with the exception of a few denuded hollows, from Milparinka to the foot of the Mount Brown Range, which rises in a north-east and south-west direction like an island out of the Cretaceous area.

Four and a quarter miles from Milparinka, on the road to the Mount Brown Diggings, a gully draining from the range has been eroded to a depth of about twenty-five feet through the Cretaceous beds, and exposed the underlying Silurian slates and sandstones striking about north-north-west and traversed by quartz veins. A promising-looking quartz reef crosses the track about a quarter of a mile further on. Then the track follows almost along the junction of the Cretaceous and Silurian which approximately marks the shoreline or beach of the Cretaceous ocean.

Where the small gullies draining off the Mount Browne Range cross this line, gold has been concentrated and worked in their alluvial deposits, especially at the "Four-mile" and "One-mile" Diggings; and also between the gullies "surfacing" has been carried on along the line of junction. At the "One-mile," the gold has been traced below the Cretaceous for about a quarter of a mile from the margin; and in one shaft, the "Lady Anne," gold is obtained in a run or lead forty feet wide with fifteen inches of wash. At Mount Browne the gold first worked in the surfacing has been followed south-west from the slate outcrop in shafts increasing in depth to two hundred and twenty-two feet, as in the "All Nations," "Golden Lake," and "Sons of Freedom," &c., which have been sunk in the Cretaceous formation, consisting of coarse, rounded quartz pebble drift, gypseous marl, quartzite conglomerate, and blue clays, with impressions of plant stems, &c.; in the "Golden Lake," "Blacksmiths," and "Waterwitch" claims, at two hundred and forty feet, heavy water was struck, and the shafts not bottomed. It is to prospect for the continuation of the gold-bearing wash into this wet ground that the miners have sought for the Government aid. A nugget of gold weighing 28 oz. has been recently obtained. These Cretaceous beds surround the end of the Mount Browne Ranges at this point, and there is much probability of rich patches of gold being got in the gravels along this old shore line on both the east, west, and south sides of the range.

The range consists of highly-cleaved vertical clay slates and sandstones, strike N. 35° W., traversed by lenticular ferruginous quartz reefs of all sizes up to fifty feet wide, some of which have doubtless supplied gold to the drifts. Gold, both alluvial and reef, is reported to have been found within six miles to the north-west and round to the west and south-west. This is a promising field and many claims might be worked on the margin of the Cretaceous; and within half a mile from this, shafts, less than three hundred feet deep might be sunk, and abundance of good water obtained, which could be pumped up to ground-sluice the deposits, and for other mining purposes.

The margin of the Cretaceous and Silurian series is about one hundred and twenty-five feet above the level of the town of Milparinka.

The surface of the country is covered with pebbles of all sizes up to eighteen inches or more, principally of quartz, with some of slate, altered sandstone, and quartzite; they have been left by wind denudation. The strong winds chiefly come from the north in the month of October.

From Milparinka, for a distance of ten miles on the road to Tibooburra, the Cretaceous formation is covered chiefly with quartz and sandstone pebbles; there are also a few patches of calcareous sandstone horizontally stratified. This class of country, which at the time of our visit was well covered with grass, saltbush, and cottonbush, extends to "Good Friday Diggings," two-and-a-half miles north-east of Mount Poole. Here are shallow alluvial and "surfacing" deposits on the south-east slopes of slate ranges, and near the edge of the Cretaceous. In the slates very large "blows," or lenticular reefs of quartz crop out and strike about north-north-west. Some of the gold obtained is water worn, and some sharp and angular; the latter has evidently been derived from some reefs close at hand. About twelve miners were working the ground. From here the track passes over the slate ranges, and immediately crosses an elvan dyke with quartz reefs on the east side of it; other reefs occur near in soft clay slates. In one of the gullies draining this slate area there are shallow gold workings. Then the track follows up the Warratta Creek to where a quartz reef has been worked to a depth of two hundred feet, but is now idle, though a battery of twelve stamps is there. In 1884 a crushing of 125½ tons of quartz yielded 39 oz. 3 dwt. of gold. Other promising reefs occur near on west side of the main worked reef. This reef has been traced for about three miles; it strikes N. 22° W. and is from six inches to two feet wide. The alluvial along the creek has been worked for gold, and one nugget obtained weighed 13 oz. The track follows up the about two miles from the reef, and then passes over a gap in the slate range at an creek elevation of four hundred and seventy feet above Milparinka, and follows down a gully which has been worked from its head for about two miles in a north-easterly direction, to where it suddenly emerges from the slate ranges and flows over the Cretaceous plains, which are pebbly with calcarous sandstone and gypseous marls, to Nuggetty Gully where the slate hills again rise out of the Cretaceous country. Along the margin of the latter, as well as on the slopes of the slate hills, there are shallow alluvial workings. These continue to Tibooburra; but the slate gives place to granite about one-and-three-quarter miles before reaching Tibooburra. Rich "surfacing" has been found more or less over the granite area, near the centre of which the town is situated. This area is in irregular outline about two to three miles in diameter. The granite is hornblendic with black mica and oligoclase felspar and traversed by veins of eurite. In one part there is a mass, twenty feet across, of large crystals of orthoclase, quartz, and yellow mica. It shows vertical, parallel cleavage joints, which split up the rock and give it the appearance of strata standing

on end. The joint fissures strike N. 35° E. The granite contains pieces of other rock. On the surface it weathers into patches of hard boulders, which show the effect of scaling and breaking up from the action of weather, probably heat and cold. Between these patches it appears to be of a softer nature, or more subject to decomposition, and has been worn to a comparatively level surface, covered with from one to six feet of alluvium, which contains gold, and has in places been wholly worked. The gold in it is scaly, but some shotty and nuggetty gold has also been found. It appears to have come out of the granite, which is traversed by a few reefs of quartz. Gold is only found in payable quantity in a belt about three-quarters of a mile wide, extending east and west across the granite. The granite is surrounded by altered slates and sandstones highly cleaved, and containing large and small lenticular reefs of quartz. One reef is about twenty feet thick. The slates strike W. 32° N., and are vertical. On the north-east and south there is only a narrow belt of slates between the granite and Cretaceous; but to the west it extends for six miles or so, forming rough rocky hills, the gullies draining from which have been more or less worked for gold, especially where the Cretaceous gravels have been denuded off the slates, as at the "Six-mile" and the "Two-mile" Diggings. The Cretaceous strata consist of shale, calcareous ferruginous sandstone and pebble cement. The surface of the ground is generally covered with pebbles, chiefly of quartz and altered sandstones. Three miles east of the town a well has been sunk through blue clay shale beds, and an abundant supply of water struck at one hundred and ninety-five feet deep; it was not bottomed. Also in Scot's well in similar strata, at two hundred feet deep, a good supply was met with, which rises sixty feet in the shaft. The Government well is in slate, and yields only a little brackish water. About one mile from Tibooburra a patch of sandstone and conglomerate, about ten chains in diameter, occurs. The sandstone forms excellent stone of white and brown colour for building purposes. It is false bedded, and somewhat resembles some of the Devonian strata, and contains obscure impressions of plants. About half a mile east of the town another small patch of these rocks, only about thirty yards across and twenty-five feet thick, rests upon the granite.

Similar rocks, though containing more conglomerate rest on the slates and cap the range about eight miles west of Tibooburra, just beyond Nuggetty Gully, thus showing that this formation must have once covered nearly all the granite and slate area of this locality; and it is evident that where it has been removed by denudation during the erosion of the valleys, the gold in it originally derived from the slates, reefs and granite has been ground-sluiced, as it were, into the shallow alluvium in the bottom and on the sides of the existing valleys. At the head of a small gully which has been worked for gold, and in which a 20-oz. nugget is said to have been obtained, a tunnel has been driven seventy-three feet into the Cretaceous conglomerate, where it rests upon the slates, and "colours" or specks of gold were obtained, but not in payable quantity.

In Nuggetty Gully a 15-oz. nugget, with quartz attached, was obtained, also smaller specimens of gold in quartz, but the gold is chiefly fine and scaly, as if derived from the laminæ of the slates as well as from quartz veins; the reefs in this locality should be tried for gold. Between the "Nuggetty" and "Easter Monday" Diggings, where some surfacing on the slates has been carried on, the thin capping of Cretaceous conglomerate will probably furnish many payable patches. Most of the workings in the alluvium and surfacing are where the Cretaceous gravels have been denuded from off the slates. This may be considered a shallow surfacing diggings, and a large amount of gold will for years be won from it. In places, however, the gold may probably be traced into deep ground in the Cretaceous, where the latter has filled irregular hollows in the slate bed-rock; but no Tertiary deep leads exist in the district, excepting, perhaps, in the Warratta Creek flat, where it leaves the hills and crosses the road from Tibooburra to Milparinka. The alluvium of this flat between the slate hills, about a quarter of a mile west of the road and north of the Warratta gate, should be prospected. The next creek flat, a short distance south of the Warratta gate, should also be prospected. To the south-east of Warratta gate the slate formation with quartz reefs continues for about five miles; and in one part, in a gully on the south-west slopes, gold in the alluvial has been worked for about half a mile, and at the head of the workings several quartz reefs cross the gully, one of which has been sunk upon for about twenty feet, and is said to have yielded gold. The slate contains cubical pyrites.

The Mount Browne Range attains its highest point (which is about four hundred and fifty feet above Milparinka) W. 20° S. from Milparinka; then in about one-and-a-half miles it terminates as a conspicuous range; but a low rise continues from it to Mount Poole. Slates with quartz reefs, crop out at intervals along this rise, and elsewhere it is covered with Cretaceous quartzites and conglomerates.

On the west side of it the surface of the Cretaceous formation stands at a higher level than that on the east side; for the drainage of a large area finds its way into Preservation Creek, through a rocky gorge eroded one hundred feet deep in the slate and diorite at Depôt Glen, where a fine waterhole exists just where the creek emerges from the gorge. Other good waterholes occur in the creek bed a little further down: on the southern bank of one is the grave of J. Poole, who was buried here 16th July, 1845, when the gallant explorer, Sturt, and his party, of which Poole was the surveyor, who were the first to visit this country, were so long detained here during a season of drought. About two miles west-north-west from Depôt Glen the Silurian schists strike about N.W. to N. 35° W., with quartz reefs of irregular extent, and pass under the Cretaceous.

Mount Poole, three hundred and eighty-five feet above Milparinka, rises somewhat abruptly—about two hundred and twenty feet—above its base, up to which the surrounding country gradually rises. It forms a rough, rocky hill about one-and-a-quarter miles in diameter, with a central peak, on which Sturt, in 1845, built a cairn of stones ten feet high.

The Mount consists of hard quartzite (porcellanite, which rings, when struck, like procelain), quartzite conglomerate, and accretionary quartzite; on the north slope white and grey clays, with ironstone patches crop out. It appears as if the Mount had been formed by a local upheaval of the Cretaceous beds, for its summit is about two hundred and sixty-five feet above the level of the highest quartzite rises, which occur between Milparinka and Tibooburra. The quartzite beds are similar to those forming the cap of "Tent Hill," eight miles north of Corona, referred to in my Annual Report for 1884*; they appear to form the uppermost beds of the Cretaceous series, as pointed out by Mr. Geological-Surveyor Brown in his report on the district in 1881. Probably artesian water would be struck at four hundred or five hundred feet if a bore were put down on the west slope of this Mount—at about one hundred feet below its summit.

The surface of the country for two to three miles from Mount Poole is thickly strewn with pebbles of quartz, boulders of quartzite, quartz, and other rocks mingled with a sandy clay. At present (September) it is covered with grass, saltbush, cottonbush, and other herbs, but in seasons of drought it must appear quite as a "stony desert."

The Silurian formation of the Whittabreena Ranges appears to come in about seven miles north-east of Mount Poole. The highest point of the Whittabreena Range is called Wizard's Peak.

On the Silurian slate formation, and especially on its margin with the Cretaceous from Mount Browne to Tibooburra, payable deposits of gold are likely to occur, and probably a Pleistocene lead may be found on the Cretaceous as a "false bottom" for a distance of half a mile from the Gorge at Depôt Glen; this ground should be prospected. The slates with quartz-reefs crop out within about two-and-a-half miles W. 30° S. from Milparinka, and a little gold has been found there.

From the foregoing observations it will be seen that within the Silurian and granite areas metalliferous lodes of value have been worked, principally containing silver, lead, gold, and tin. Much of the country has not yet been prospected, so that the mining industry in this district, which has already attained a position of importance, will undoubtedly increase and support a large and thriving population. Mr. Warden De Boos reports that the quantity of gold raised during 1887 in the Mount Browne and Tibooburra Gold-fields was 4,709 oz.; and Mr. Wyman Brown, Warden of the Silverton Division, states that the value of the minerals exported in 1887 from the district under his charge amounted to £600,000, of which the Broken Hill Proprietary Company's Mine contributed lead and silver to the value of £464,190, from which £200,000 were paid in dividends.

A great desideratum is a good water supply. The low average annual rainfall, about nine inches, in this arid region precludes the permanency of a large supply in the natural holes in the water-courses; but it has been proved to be sufficient to afford

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* Annual Report, Department of Mines 1884, p. 148.

an ample supply if large and deep tanks or dams were constructed to conserve it, and for which the hilly metalliferous country offers suitable catchment areas and sites. In the same country, that is, in the Palæozoic rocks, there is but little hope of obtaining, either by boring or sinking, an abundant supply of water fit for domestic use. However, the surrounding Cretaceous strata will be found to yield an unlimited artesian supply of fresh water.

Where the soil does not contain much saline matter, irrigation for cultivation purposes answers admirably. In the garden of Mr. Harvey Patterson, at Corona Station, also in the Chinamen's gardens at Tibooburra and Milparinka, which are irrigated with water from wells, I saw in the month of September splendid crops of vegetables, cabbages, onions, parsnips, and carrots four inches in diameter, white turnips five inches, and wheat standing from three to four feet high.

We cannot doubt, therefore, that the natural resources of this portion of New South Wales are sufficient, if intelligently made use of, for the settlement and health of a large population.

II.—Report on the Discovery of Human Remains in the Sand and Pumice Bed at Long Bay, near Botany: by T. W. EDGEWORTH DAVID, B.A., F.G.S., Geological Surveyor, and ROBERT ETHERIDGE, Junr., Palæontologist.

[Plate I.]

I.—Geological Description of the Locality.

ON April 14th ultimo, when examining the Sand and Pumice bed at Long Bay, we accidentally discovered in it portions of a human skeleton. This bed forms the surface of a tongue-shaped flat at the mouth of a small creek opening into Long Bay. To the north-east and south-west this flat is bounded by low hills of Hawkesbury Sandstone, partly covered by blown-sand, now overgrown by trees and scrub. To the north-west it gradually ascends and narrows until lost in the sand-hills similarly covered with vegetation, which form the source of the creek. Seaward, where the flat is about ten chains wide, it terminates in a low cliff of Hawkesbury Sandstone, the base of which is hardly removed above the level of high water. At the south-west end of the flat the cliff is twenty-six feet high, and from here it declines towards the right bank of the creek, where it is seventeen feet above high water-mark.

Three deposits are exposed in this cliff-face (see longitudinal section Pl. I, fig. 1) and are from below upwards :—

1. Hawkesbury Series.
2. Consolidated Sand, formed from waste of No. 1. *
3. Blown Sand and Pumice bed, with marine shells.

No. 1. The Hawkesbury Series consists of a whitish-grey quartzose-sandstone, with occasional lenticular beds of small quartz pebbles, and near the sea-level an intercalated bed of sandy-shale. At the left of the section, this series consists of a massive bed of a rather soft clayey sandstone, then twelve feet in thickness. Above this is a bed of dark-grey sandy-shale some two feet in thickness. This is again succeeded by a ferruginous decomposed sandstone, with pebbles and grit in places. The Hawkesbury rocks here dip south-westerly at a low angle, but a few yards to the right they roll over sharply to the north, so as to bring the shale-bed down to the high-water level.

No. 2. The Consolidated sand consists of sand with small fragments of quartz, and is here four feet thick, but increases on the right of the section to twenty feet. This deposit rests in a hollow of the Hawkesbury Series, partly due to this roll. From the point where the skeleton was found the consolidated sand thins somewhat towards the creek owing to its surface slope in this direction, and to the rising again of the underlying Hawkesbury Sandstone. Its upper surface for about 1 foot downwards is blackened with peaty material and very much hardened, showing clear evidences of having been at one time a land surface. No organic remains of any kind, nor any fragments of pumice were found in this bed. The surface of the consolidated sand was slightly hollowed at the point where the remains were found, but with this exception it was remarkably even, as far as could be seen in the excavation made, and along the cliff face.

No. 3.—The Blown-sand bed with shells and pumice is a loose whitish-grey sand, which was originally, no doubt, blown into its present position, and subsequently became overgrown with vegetation. The bed commences about one chain to the right of the point A in the longitudinal section, and extends to the right bank of the creek, a distance of three chains, maintaining a pretty uniform thickness of three feet. The fragments of pumice vary from one to two inches in diameter, and are most numerous for about two chains from the creek in a westerly direction, whence they die out gradually. The bed is here seventeen feet above high-water mark, and this is the greatest height to which we have been able to trace the pumice at this locality. Scattered through the turf, and the upper part of the bed, are numerous large shells,

* Confirmatory evidence to the effect that this formation is distinct from the Hawkesbury Series, and is not merely the latter decomposed *in situ*, is supplied by a section recently observed by one of the authors near the south end of Fingal Bay, Port Stephens, where a bed of consolidated sand, about fifteen feet thick, similar to that at Long Bay, and probably of Tertiary Age, overlies a Palæozoic Porphyrite. The intermixture of peaty material with the consolidated sand at Fingal Bay proves clearly that it belongs to a far more recent date than that of the Hawkesbury Series.

chiefly belonging to the genera *Turbo* and *Triton*, with a few pebbles of sandstone, the largest of which is about nine inches in diameter. The surface of the flat, although now cleared of timber, shows evidence, chiefly in the form of old large stumps, of having supported as vigorous a vegetation as the surrounding low hills. It is further quite clear that this bed acted as the soil of these trees and shrubs, and was not simply accumulated round the trunks of pre-existing vegetation.

II.—Remarks on the Skeleton and its position.

The skeleton was first noticed owing to the fact that the lower end of the right fibula projected about an inch beyond the vertical face of the blown-sand, just at its junction with the consolidated sand. This bone had been so exposed, owing to a foot-path having been made in the face of the cliff. The trend of the cliff face is about E. 25° N., and the fibula with the tibia beside it were lying about N. 30° W (Pl. 1, fig. 3). Following them in a direction N. 38° W., their upper ends were found in apposition with the patella and femur. About six inches to the right were the tibia and fibula of the other leg, lying nearly parallel with them, and also joined to their respective patella and femur. The femora were lying in a direction about W. 10° S., and resting on one of them, and attached to it by matrix were two specimens of the marine bivalve *Circe scripta*, Linn. The heads of the thigh bones were found inserted in the acetabula ; and the front of the pelvis was upwards, the right side being a little higher than the left, as though the body had reposed partly turned over on its left side. Under the left ilium were two stone implements, the smaller resting on the larger, and the convex valve of *Pecten funatus*, Reeve, whilst close by were several specimens of the *Circe*, some having the valves united. The ilia were united by only two vertebræ of the sacral series, and the others were not found, with the exception of the terminal bone of the coccyx. In contact with the upper sacral vertebræ was part of the spinal column, consisting of five lumbar and three dorsal vertebræ. The lie of the column was about W. 35° N. Portions of seven ribs were found partly resting against the vertebræ, and partly underneath. On the north side of the column, and close to the uppermost dorsal vertebræ, lay the lower arm bones of both arms, lying in a direction about N. 18° E. The bones of the hands were found in their proper places. Subsequently some of the bones of the feet were found by Mr. C. S. Wilkinson and Mr. J. E. Carne in the fallen sand at the foot of the cliff. It will thus be seen that of the whole of the upper portion of the skeleton, comprising the remaining vertebræ, humeri, sternum, clavicles, &c., and skull, no trace could be found after a very diligent search.

The bones were mostly in a fair state of preservation, though a few were so friable as to hardly bear lifting. None of them show traces of having been subjected to any kind of violence.

From the fact that the epiphyses of the tibiæ, femora, and radii, &c., were unossified, and the sacral bones not anchylosed, as well as from the general slenderness of

the bones, our friend, Dr. H. C. Moir, of Summer Hill, who kindly examined them, is of opinion that they belonged to a young person not exceeding twenty years of age. The narrowness and shape of the pelvis clearly show the skeleton to have been that of a male.

The bones were resting immediately on the discoloured and hardened surface of the Consolidated Sand (Pl. 1, fig. 1, No. 2), which had been roughly excavated for their reception to a depth of about six inches, and forming an oblong depression three-and-a-half feet by two-and-a-half feet. The hollow was scarcely large enough to have held the skeleton when complete, if placed in the ordinary prone position. The bones were surrounded and overlain by loose whitish sand of the Blown-sand and Pumice bed (*Ibid*, No. 3), but throughout it were lumps of the loamy and hardened upper portion of the underlying bed (*Ibid*, No. 2), varying in size from that of a marble to that of an orange. These lumps were met with laterally only as far as the edge of the hollow, and vertically to within about one foot of the grass-level. The latter superincumbent material consisted of loamy Blown-sand forming the present land surface. A great number of specimens of *Turbo torquatus*, Martin, mostly broken, were distributed throughout this top layer, with occasional fragmentary examples of *Triton Spengleri*, Chemnitz. Four fragments of sandstone were found in the turf just over where the skeleton reposed. These were from six to nine inches, or even a foot in diameter, and rounded, evidently having been carried up from the beach. Similar pieces of sandstone were observed close to the right bank of the creek in the pumice bed.

III.—Objects immediately associated with the Skeleton.

As before stated, these consisted of two stone implements and some marine shells. The former are composed of a dark micaceous flagstone, which may have been obtained from local beds in the Hawkesbury Series. The larger (Pl. I, figs. 4 and 5), which is roughly oblong in shape and angular, measures five inches long by three wide, and is from three-eighths to half-an-inch in thickness. One of its longer margins has been ground down on both sides, so as to form a tolerably sharp-cutting edge. The smaller implement (Pl. I, figs. 6 and 7), is oval, and measures two inches in its longest diameter by one-and-a-half inches in the opposite. Mr. J. Brazier, C.M.Z.S., has examined these weapons at our desire, and considers them to be aboriginal skinning-knives, though of an unusual type, and one with which he is not well acquainted, as well as of considerable antiquity. We have, however seen a very similar knife to the larger of our specimens taken from the grave of an aboriginal in a "Kitchen-midden" at North Harbour, who perhaps died from the epidemic of small-pox, which raged amongst the blacks at Port Jackson at the commencement of the present century. It is possible, and even probable, that the implement found by us may be far older than that date.

The associated shells have been already mentioned, viz., *Pecten funatus*, Reeve, the convex valve found under the left ilium; *Circe scripta* Linn., two examples

attached to one of the femora, and several under and around the arms. In the case of this bivalve, several of the valves were united, and one of them was found to be empty, although the others were partially filled with peaty matrix. Both species are edible.

IV.—Evidence for and against Burial.

That the skeleton was buried by human agency in the first place, and covered up to a great extent naturally by the drifting of sand afterwards, strong proof is afforded—

(1.) By the existence of the hollow in which it was lying.

(2.) By the fact that the material broken out of the depression was found to be scattered through the loose sand for a height of two-and-a-half feet above the bones.

The latter fact proves conclusively that this hollow was formed artificially, and was not a natural depression in the old land surface.

Glancing at the other phase of the question, viz., as against the fact of burial, we find that the only argument of any weight is the incompleteness of the skeleton. The body must obviously have been complete or incomplete at the time of its interment. If complete, and if it had been buried, as we now find it, under at least three feet of sand, it is scarcely credible that the only beast of prey of any capacity existing on the continent, as the native dog, could have scratched to such a depth and dragged away the upper part of the body and skeleton. On the other hand, if incomplete, the latter must have been severed either by man or animals. It is, however, difficult to conceive that aboriginals (and there seems little doubt that this is the skeleton of one), could have accomplished such a task, armed with no more serviceable tools than sharpened stones. If it be granted that the body was severed previous to burial some traces of violence could not fail to have been left on the bones at the point where the severance was made. As a matter of fact, however, neither the uppermost dorsal vertebra, nor the heads of either the ulnæ or radii show the least sign of anything of the kind.

The occurrence of the scattered and rounded pieces of sandstone in the uppermost layers of the Sand and Pumice Bed (Pl. 1, fig. 1, No. 3), over the spot occupied by the skeleton is probably accidental. It does not appear to have any relation to the custom prevalent with some of the Victorian blacks of placing the body in "a stone-lined trench cut in the ground."* That a custom somewhat analogous to this existed amongst our coastal blacks is evident. Mr. P. R. Pedley has shown us an aboriginal burying-place in Port Jackson, where stones, as proved by himself, had been placed immediately over the spot occupied by the corpse, the skeleton in this case having been found about one foot below them; but here the slabs were placed with method, and, clearly for a purpose.† The stones in the highest layer of the Sand and Pumice

* R. B. Smyth, Aborigines of Victoria, 1878, I, p. 99.
† This method of protecting the dead seems to have been widely distributed.

Bed at Long Bay are much smaller than those obtained by Mr. Pedley, and as others were observed at another point, at least two chains distant, they may have had no connection at all with the burial.

Referring again briefly to the incompleteness of the remains it is a remarkable fact that the depression in which the bones lay was only sufficiently large for them in their incomplete condition. It could not have received a corpse buried in the ordinary extended position. But amongst certain tribes of Australian blacks it was the custom to inter it "bent and doubled, so as to admit of its being laid in a small space,"* usually with the thighs drawn up against the trunk.† This, however, could not have been the case in the present instance, as evinced by the position of the skeleton shown on the plan.

V.—Probable Explanation of the Conditions of its Occurrence.

Adopting the theory that the body was buried by human agency, and in a complete state, we venture to suggest the following explanation of the conditions of its occurrence :—At the time of the youth's death the top of the old land surface (Pl. 1, fig. 1, No. 2) was thinly covered with drift sand to the depth of a few inches, for, had it acquired anything like its present thickness, the aboriginals would probably have interred the remains in this loose sand without going to the trouble of excavating in the hardened material of the old land surface.

There being at the time no loose sand of serviceable thickness available, a shallow excavation was made to the depth of about six inches, and the body laid in it, the head and shoulders perhaps resting on the edge of the hollow. It was then covered partly with the excavated fragments of consolidated peaty-sand, and partly with what little loose sand was lying about. After, or during decomposition, the covering material was either blown away or scratched from around by wild dogs, and the missing portions of the body dragged away by the latter. The drifting of the sand then continued until it reached the level of the present surface, when vegetation sprang up, and the whole was gradually bound and compressed into its present solidified form, and supported trees of considerable size, as shown by the stumps still remaining in the ground. Such strong signs of marine denudation are apparent in the bay, that the cliff without doubt then extended further seaward than it does at the present day.

VI.—Age of the Skeleton.

The only substantial evidence for assigning a comparatively recent date to this burial is in the fairly good state of preservation of the bones. This can, however, to some extent be accounted for by the dry nature of the surrounding soil and excellent drainage of the hollow in which they lay.

* Smyth, *loc. cit.*, p. 27.
† This appears to have been the position adopted by the coastal blacks of the Port Jackson district.

On the other hand, the evidence for tracing these remains back to a very early period of man's occupancy of this country may be briefly summed up as follows :— First, the quantity of the superincumbent material accumulated subsequently to the interment; secondly, the position of the grave with regard to the then and now-existing cliff face, illustrating the amount of denudation which must have taken place; thirdly, the probable antiquity of the associated stone implements.

An estimate of the rate of increase of Post Tertiary deposits is governed by such variable data that it is hardly possible to assign even an approximate date to the burial of the Long Bay's skeleton. It must, however, be very old—old enough to allow a well-marked geological deposit, such as the Sand and Pumice bed, to accumulate over it. The advent of man on this continent is still wrapt in obscurity, and probably will remain so—certainly until we possess more definite geological evidence of his presence than we at present have before us. So little general interest has been manifested in the natural history of the aboriginal inhabitants of this part of Australia as almost to amount to a national disgrace. Their burial-mounds, "Kitchen-middens," and other traces likely to become geologically interesting, are disappearing so fast through the rapid march of "improvements," that ere long few or no traces will be left. It is, therefore, much to be regretted that some systematic and scientific method of investigation of the early history of this fast disappearing and ill-used race be not forthwith established. We have in the present case probably one of the earliest traces of man yet discovered.

We are acquainted with but two other instances of human traces occurring under geological conditions. The first is that of the "stone hatchet found on the Bodalla Estate, near Moruya, in the alluvium, at a depth of fourteen feet from the surface."* Mr. Wilkinson was informed that a large tree was growing immediately on the surface over the spot where the hatchet was discovered. The second was observed by Mr. C. S. Wilkinson in 1864, when making a survey of the Otway Ranges, in Victoria. In the sand dunes, two miles east of Cape Otway light-house, flint chips, a sharpened stone tomahawk, and several bone spikes or needles were found, relics of the past tribes of the Cape. At about the same distance from the light-house one of the writers, in company with Mr. H. Ford, of that place, obtained a similar bone spike in a mixture of beach material, pebbles, humus, and broken shells, resting on the Mesozoic Carbonaceous sandstone, forming the high cliffs of the Cape, and apparently intermediate between that deposit and the overlying dunes.† Remains of this nature, lying, as they did, beneath sand dunes at least two hundred feet high, must have been of great antiquity.

* C. S. Wilkinson, Mineral Products, &c.—2nd edit, 1867, p. 90.
† Etheridge, junr., "Observations on the Sand Dunes of the Coast of Victoria," *Trans. R. Soc. Vict.*, 1876, xii, p. 3.

III.—Petrographical Notes on the Eruptive Rocks connected with the Silver-bearing Lodes at Sunny Corner, near Bathurst, New South Wales: By William Anderson, Geological Surveyor.

[Plates II and II *a*.]

The igneous rocks in immediate connection with the Silver-bearing Lodes at Sunny Corner, some twenty miles east of Bathurst, consist of quartz porphyries and non-porphyritic felsites. They are intrusive, and have been erupted through a series of Palæozoic rocks, probably of Silurian age. They occur in four isolated areas (Pl. II); but although their outcrops are separated at the surface by Silurian sedimentary rocks, yet there is no doubt that they had their origin in the same eruptive force. In fact, the continuity of the three larger areas is proved by the occurrence of quartz porphyry in the shaft of the Great Mitchell Extended mine, on Mineral Lease 20, parish of Castleton. One of the larger areas forms the hill immediately to the south-west, another lies to the south-east of the township of Mitchell, while the third forms Township Hill. The fourth and smallest area lies about two miles to the north of the township, but is, however, connected with one of the felsite dykes which runs north from Township Hill, by a narrow belt of highly altered, and probably faulted Silurian strata. The two larger areas to the south of the township consist of quartz porphyry, but no metalliferous lodes have been discovered in immediate connection with them, although numerous gold-bearing quartz reefs have been opened up, both along their lines of contact with the slates and in their mass. The principal silver lodes occur in connection with the eruptive rock forming Township Hill, which is one of the highest hills in the neighbourhood. At its southern end the rock is a typical quartz porphyry, while towards the north this intrusive mass breaks up into three well-marked dykes consisting of non-porphyritic felsite, and traversing the slates in a general northerly direction. It is in connection with these narrow felsite dykes that the chief silver lodes occur, the Sunny Corner mine being connected with the western; the Great Western, and Silver King mines with the central; and the Silver Queen mine with the most easterly. The Nevada mine is situated near the western boundary of the smallest of the eruptive areas, about two miles to the north of the township.

Besides the acquaintance with these rocks which I gained in the field whilst making a geological sketch map of the neighbourhood of the silver lodes, in the latter end of 1886, I have examined microscopically a series of thirty thin rock-slices taken chiefly from the intrusive mass to the south-east of the township, from the Township Hill, and the felsite dykes connected with it, and from the Nevada mine. Although these sections are taken from intrusive masses which in all

probability were erupted at one and the same time, yet, owing to the varied conditions under which different portions of them consolidated, they present in their extreme variations of rock structure two distinct varieties of rock, quartz-porphyry and non-porphyritic felsite. There is, however, a distinct transition from the true quartz porphyry into the non-porphyritic felsite by the lessening in size and abundance of the porphyritic constituents. This gradation is seen in the series of sections taken from south to north on the Township Hill, and shows conclusively that the non-porphyritic felsite dykes are simply offshoots from the general eruptive mass, and that their fine-grained structure and want of porphyritic ingredients are due to the rapidity with which they parted with their heat, causing them to consolidate before the felspar and quartz had time to separate out in a porphyritic form. In all the sections of this intrusive rock the devitrified base is seen microscopically to be of a similar nature, and the only difference macroscopically between the two varieties is the presence of porphyritic minerals in the quartz porphyries. The felsites are in most cases distinguishable with difficulty, even by the aid of a lens, from the altered pyritous slates which they traverse.

The quartz-porphyry is of a light gray, brown, or reddish colour, the last being, however, rare. Specimens taken from different parts of the out-crops present different varieties of structure. Besides the typical form of quartz-porphyry which shows no characteristic peculiarity of structure, there is the banded variety showing fluxion structure, and the sphærulitic variety, where the base is crowded with sphærulites. Microscopically, the devitrified portion of the base is made up of microcrystalline quartz and felspar grains, in some sections the former mineral predominating, and in others the latter. These minute quartz and felspar grains can only be distinguished by their action on polarized light under a high power. Between crossed nicols, however, besides this individualized quartz and felspar, fine reticulations which have no action on polarized light are seen inclosing the crystalline grains of the devitrified portions of the base. This is probably a microfelsitic or still glassy portion of the base. The base is never altogether colourless, but is usually of a yellowish-brown, or rarely red colour, due to the presence of ferrite in varying abundance. It has generally a more or less streaky appearance, and this is a very prominent feature in those sections which show a distinctly fluidal structure, the interbanding of almost colourless and red ferrite stained portions being very well marked. Ferrite is more or less abundant in the base of all the sections, and is usually disseminated generally through it, sometimes assuming a minutely dendritic form, and often aggregated into dark brown or nearly black irregular masses, and streaks, which sometimes form a black border to the porphyritic minerals. In those portions of the rock which show fluxion structure the ferrite is arranged in bands alternating with the lighter coloured material of the base, and thus making the evidence of flowage very distinct. Iron pyrites can be distinguished in most of the

slides, and in some of them it is very abundant in excessively minute crystals. It occurs in all the various sections of a cube, and is sometimes macroscopic in size. Much of the ferrite in the rock has been derived by decomposition from this mineral. Infiltrated secondary quartz occurs, filling small cracks, and irregular-shaped areas, and also, scattered through the base very minute irregular cavities occur, which are filled with clear quartz, which resembles more the secondary quartz filling the cracks and larger areas than either the porphyritic quartz, or the quartz grains of the devitrified portions of the base. This is no doubt a secondary product, and is similar to the "infiltrated network quartz," described by Irving as being present in the bases of the porphyries and felsites of the Lake Superior region of North America.* It is not very abundant, but it can be recognized more or less in every section. Light, green coloured, fibrous epidote is sometimes present in considerable abundance. The porphyritic ingredients are quartz, felspar, and occasionally hornblende. A few of the porphyritic crystals show the remnants of crystalline edges, having the angles rounded off, while the majority, chiefly the quartzes, are much broken and shattered, showing that after their crystallization their edges and angles have been partially redissolved and many of the crystals cracked, due no doubt to considerable movement having taken place in the still plastic magma. This movement is still further evidenced by the presence of well-marked fluxion structure in some portions of the rock. The prophyritic quartzes occur more abundantly than the felspars. They vary greatly in size from almost microscopic blebs and crystals to macroscopic forms one-eighth of an inch in diameter. In shape there is also great variation, from ill-defined crystalline forms to blebs of most irregular outline, which is often picked out with a dark border of ferrite. The edges of the quartzes are often indented by irregular semi-inclusions of the base, while many of the cracks are filled with the same material. No doubt many of these tubular looking cracks have been channels of ingress for some of those portions of the base which now seem to form isolated areas in the interior of the prophyritic quartzes; but some of these inclusions of the base were probably caught up during the crystallization of the prophyritic quartzes. They invariably present the same partially devitrified structure which is characteristic of the general base. The non-occurrence of inclusions of the base in a vitreous condition in the prophyritic minerals, would, I think, tend to show that the devitrification of the base was not a subsequent result, but that it took place during the cooling of the vitreous glassy magma. Some of the quartzes are wonderfully free from inclosures of any kind, even the most minute, but generally they contain the usual microscopical globular inclusions arranged in minutely beaded strings, and scattered indiscriminately throughout the crystals. A few, included microliths, occur in the form of minute prisms, but they are rare.

* U. S. Geological Survey (King's), 1883, vol. v. (Monograph on the Copper-bearing Rocks of Lake Superior, by R. D. Irving), p. 100.

The porphyritic felspars are not very abundant, indeed in some sections they are not present at all. They include both orthoclase and plagioclase, and are, as a rule, decidedly crystalline in outline. They are usually rendered somewhat opaque by the presence in them of decomposition products and ferrite. In the plagioclase crystals the striations are still recognisable, because of the arrangement of the opaque material along their planes of cleavage. The largest felspars exceed the largest quartzes in size, but are not nearly so abundant. Very minute lath-shaped crystals of felspar occur scattered through the base, in some sections forming quite a distinctive feature.

In a few cases hornblende enters into the composition of the rock as a porphyritic ingredient. It is of a greenish colour, and is rendered almost opaque by black bands of ferrite. A few clear spots and lines, which show pleochroism in polarized light, are still present in the greenish black mass.

In some slides microscopic hexagonal sections of iron pyrites occur porphyritically developed, although this ingredient is generally in minute crystals scattered through the base.

The first four sections are from M.L. 11, Parish of Castleton, and were cut from specimens taken within a few yards of each other. In No. 8 (Pl. II, fig. 1), the porphyritic quartzes still retain portions of their crystalline edges, although their angles have generally been corroded. They contain numerous isolated inclusions of the base, which are similar in structure to the general base. Large porphyritic felspars are rare, and minute sections of iron pyrites are abundant. A few porphyritic hornblendes are present. In section No. 9 the base contains large numbers of microscopic, lath-shaped crystals of felspar. The quartzes are much shattered, and numerous porphyritic felspars occur. In this and the preceding section there is a peculiar arrangement in the secondary quartz, which fills the larger areas in the base. These areas, and many of the secondary quartz individuals which polarize in the same colours, are included within boundaries which are botryoidal in form. These botryoidal boundaries are well marked from the accumulation on them of ferrite grains. In the former section (Pl. II*a*, fig. 1), minute fibrous-looking radiations pass from these botryoidal outlines into the neighbouring quartz individuals. Beautiful dendritic masses of ferrite occur in the secondary quartz. Nos. 10*a* and 10*b* have a brecciated appearance from being divided up into irregular areas by streaks of ferrite and secondary quartz. Numerous clouded porphyritic felspars, and nearly opaque hornblende forms are present.

Nos. 11*a* (Pl. II*a*, fig. 6), and 11*b* (Pl. II*a*, fig. 2) from M.L. 88, Parish of Castleton, show a decidedly sphærulitic structure. Most of the base is formed of individualized quartz and felspar grains, together with abundant fibrous epidote, which is sometimes radially arranged. Scattered through the base are numerous sphærulites which in some parts are aggregated together so as to form wholly

sphærulitic areas. They generally appear, however, dotted over the sections, and have ill-defined more or less irregular outlines. From a darker centre, alternate light and dark radiations pass to the periphery, where they gradually merge into the surrounding base. The porphyritic quartzes are small, the chief porphyritic ingredients being much decomposed and clouded felspars, principally plagioclase. Much infiltrated secondary quartz is present. Nos. 12*a* and 12*b* (Pl. II*a*, fig. 3) from the shaft of the Great Mitchell Extended Mine on M.L. 20, Parish of Castleton, show well-marked fluxion structure, the lines of flowage being made very evident by the arrangement of the base in alternate light and dark bands, which sweep round the porphyritic quartz, hornblende, and felspar crystals in the most graceful curves.

Nos. 13*a* and 13*b*, from the Silver Prince Mine, on M.L. 84, Parish of Castleton, are only exceptional from the enormous abundance of secondary infiltrated quartz of ferrite, and which gives them a distinctly red colour.

Nos. 14*a* and 14*b*, from M.L. 7, Parish of Castleton, show indistinct fluxion structure, which is, however, not nearly so well marked as in Nos. 22*a* and 22*b*. The porphyritic minerals are chiefly quartz and hornblende. Irregular lines of ferrite are abundant, and calcite is present no doubt as a secondary product.

Nos. 15*a* and 15*b* (Pl. II*a*, fig. 4) from the Tonkin Mine, on M.L. 56, Parish of Castleton. These have a reticulated appearance, due to the abundance of ferrite streaks traversing the base, and encircling in a concentric manner the peripheries of the porphyritic quartzes, which are circular in outline. This is probably indistinct fluxion structure. Secondary quartz and ferrite are abundant.

No. 16, from shaft of Silver Queen Mine, on M.L. 45, Parish of Coolamigal. The porphyritic minerals, which are chiefly quartzes, in this and the next section, are just large enough to be seen macroscopically. Both sections show indistinct fluxion structure.

No. 17, from end of drive Silver King Mine, on M.L. 62, Parish of Castleton. Microscopic hexagonal sections of iron pyrites occur one-twentieth of an inch in diameter.

These two last sections present an intermediate structure between the true quartz porphyry and the non-porphyritic felsite, being micro-porphyritic felsites.

The non-porphyritic felsites occur as dykes, traversing the Silurian strata, and are a northern extension of the quartz-porphyry of Township Hill. There is so great a similarity in the minute structure of the various sections that it will be unnecessary to describe each one in detail, so that only those which present variations from the common type will be mentioned. Microscopically they resemble in a great degree the base of the quartz porphyries, consisting of a devitrified microcrystalline aggregate of quartz, felspar, and iron pyrites, together with a non-polarizing material, which is either a glass or a microfelsitic substance. The felspar ingredient is more

distinct than is the case in the base of the quartz-porphyries, and is in the form of minute lath-shaped microliths. Iron pyrites accurs abundantly in minute crystals in most of the sections. In Nos. 18*a*, 18*b*, 18*c* (Pl. II*a*, fig. 5), from No. 2 level, Sunny Corner Mine, they are not scattered uniformly through the section; but in some parts are individually larger and more widely apart than in others where they are smaller and closer together. Besides occurring in square sections, singly and in aggregates, they are present in a rod-like form. Many of these aggregates surround minute portions of the microcrystalline felsite in which they are imbedded. This is well seen in No. 19, from M.L. 53, Parish of Castleton. Possibly much of the iron pyrites may be of secondary origin. Ferrite is sometimes very abundant in grains and patches. In No. 20, from No. 4 level, Sunny Corner Mine, it is present lining the cracks, which it sometimes fills. Fluxion structure is present in No. 21*a* and 21*b*, from Sunny Corner Mine. Secondary quartz is generally present filling minute veins and small cavities. No. 19 is quite saturated with secondary quartz, and under polarized light the most prominent feature in the section is the innumerable minute irregular cavities filled with it.

The conclusions that seem to follow from a minute study of these eruptive rocks are, that considerable movements took place in the intruded rock-mass prior to its complete solidification, and subsequent to a partial crystallization of its mineral constituents. These movements are evidenced in different ways in different portions of the rock-mass. At one part we have the shattered porphyritic quartzes, at another the presence of fluidal structure, and at another the rock possesses a brecciated character.

The entire absence of perlitic structure, and the fact that none of the isolated inclusions of the base in the porphyritic quartzes occur in a wholly glassy condition (which would probably be the case if the rock had in the first instance solidified into a glassy rock of the rhyolite type) tend to show, although negative evidence, that the crystallization of the various constituents of the rock took place during its solidification, and that it was not due to a subsequent molecular change in the base of the rock after its solidification in a glassy state. In other words, that the crystallization of the various minerals has been of primary origin, and that the rock is not a devitrified rhyolite.

The contraction which the whole intrusive rock-mass underwent during its solidification was no doubt the primary factor in the formation, along its junction with the sedimentary strata, of the cavities, in which were subsequently deposited the lodestuffs containing the silver ore. There is, however, sufficient stratigraphical evidence to show that these cavities were further enlarged, and other cavities formed by subsequent movements which took place along the junction between the two rocks. But whether the various minerals and metalliferous ores were introduced into these fissures from below during the later movements which caused their enlargement, or whether they were slowly deposited by precipitation from the

waters which percolated through the eruptive rock, during its passage taking up in solution the various metals and ores, and redepositing them in the fissures, can only, to a certain extent, be proved by the careful study and comparison of the chemistry of the lodestuff, and the intrusive rock respectively. The only fact observed in this relation is that in some places, particularly in the neighbourhood of the Sunny Corner Mine, the eruptive rock contains the sulphides of the various metals which are present in the lodestuff, filling the fissures close by. The presence of sulphides in such a position may, however, be explained by the fact that they might have been deposited in the decomposed portions of the eruptive rock, by infiltrating water coming from the lodes, bearing the sulphides in solution.

IV.—On the Occurrence of a Coral, intermediate in its Structure, between the Genera *Lonsdaleia* and *Spongophyllum*, in the Upper (?) Palæozoic Rocks of New South Wales: by R. ETHERIDGE, Junr., Palæontologist.

[Plate III.]

THE genus *Lonsdaleia* was established by Prof. McCoy* for a group of Carboniferous Rugose Corals, possessing a peculiar tripartite structure. To use his own words, the corallum is "internally composed of three areas; 1st, a cylindrical, defined, complex axis composed of irregularly blended vesicular plates; 2nd, a cylindrical, defined area of strong, vertical, radiating lamellæ, connected by thin, transverse dissepiments, only visible in the vertical section; 3rd, a wide, largely cellular outer zone between the vertical lamellæ, and the external wall of the stem, composed of much-curved vesicular plates extending obliquely upwards and outwards." But to speak in more recent terminology, the "corallum is compound, fasciculate or astræiform, increasing by calicular gemmation. Each corallite is provided with a distinct wall; and an inner mural investment is usually developed. The centre of the visceral chamber is occupied by a very large, somewhat cylindrical columella, formed of twisted lamellæ. A well-developed tabulate area of close-set tabulæ, surrounded by an exterior vesicular zone of large-sized vesicles. The septa are present in the central area, most of them falling short of the columella; but they are not continued through the peripheral vesicular zone to the outer wall.†

* Annals Mag. Nat. Hist. 1849, iii, p. 11.
† Thompson and Nicholson. Annals Mag. Nat. Hist. 1876, xvii, p. 300.

The corallum is always compound, and either astræiform, or in some degree fasciculate. The anatomy of the genus has been fully worked out by Messrs. Thomson and Nicholson, and by Messrs. Waagen and Wentzel,* and from their combined writings an excellent idea of its structre can be obtained.

Lonsdaleia is much restricted in its geological range, "not having been hitherto found to transcend the limits of the Carboniferous rocks." The object of the present paper is to describe a rather aberrant form, the first even provisional evidence of the genus, yet found in Australia,† or, on the other hand, if it be not intermediate between this and *Spongophyllum*. The rocks in which the specimens were obtained are certainly older than Carboniferous—they may perhaps be Devonian; but as no definite geological examination of the district has yet been made, and the geology is said to be much complicated by metamorphic action, the exact horizon must at present remain an open question. It is, however, interesting to note that the probable lower stratigraphical position of this coral is accompanied by a marked modification of structure to that of those found in higher rocks.

Spongophyllum, on the contrary was established by Messrs. Edwards and Haime‡ for a massive and astræiform Devonian coral, in which the corallites are prismatic, and united together by their external walls, but without internal walls or columella. The septa are numerous, very thin, and more or less lost in the vesicular tissue, which nearly fills the visceral chambers. The centre of the latter is occupied by horizontal tabulæ. Recently, however, the characters of *Spongophyllum* have been much enlarged by Dr. Clemens Schlüter, and it is in this sense that the Australian coral approaches the genus.§

In the present instance we are dealing with a coral possessing the typical features of *Lonsdaleia*, except that each corallite seems to be practically devoid of a columella, whether formed of twisted lamellæ or styliform. Unlike the genus *Thysanophyllum*,‖ however, the place of the columella is not taken by a well-marked tabulate area, but the septa merely meet in the centre, or at the most hardly intermingle with one another.

In the present species which it is proposed to provisionally place in *Lonsdaleia*, and call *L ? (Spongophyllum) bipartita*, the corallum is massive and astræiform, probaly forming large hemispherical masses, and is highly silicified. The growth of the coral is fairly uniform, although a few irregularities occur here and there. In general appearance it corresponds with such species as *L. floriformis*, Fleming, sp., amongst British forms; *L. papillata*, Fischer, sp., representing the Russian species, and to some extent *L. salinaria*, W. and W., of the Salt Range Series in India.

* Pal. Indica (Salt Range fossils), 1885, ser. xiii, fas. 1, No. 6, p. 892.

† In the Catalogue of Australian Fossils (8vo. Cambridge, 1878), p. 37, I, by a pure oversight, referred McCoy's *Strombodes australis* to the genus *Lonsdaleia*. This is an error.

‡ Archiv. Mus. Hist. Nat. Paris, 1851, v. p. 425.

§ Ueber einige Anthozoen des Devon. *Verhandl. Naturhist. Vereines Preuss. Rheinlande u. Westfalens*, 1881, xxxviii, heft, 2, p. 189.

‖ Nicholson and Thomson, Proc. R. Soc. Edinb., 1876, ix, p. 149.

The corallites are polygonal in outline (pentagonal, quadrangular, or hexagonal), very unequal in size, and firmly united by their walls. They are surrounded by a thin and pellicle-like epitheca, bearing broad longitudinal sub-angular riblets, and distant transverse accretion ridges. The largest corallite observed possessed a diameter of fifteen m.m., but the mean appears to be ten m.m. The outer walls are distinctly developed, but thin, simple, and somewhat flexuous, and at the upper surface of the corallum project above the general outline of the latter. The calices are deep and infundibuliform, the peripheral surface being very oblique, and the visceral chamber deeply excavated.

In a transverse section (Pl. III, fig. 5) the exterior vesicular zone is very well marked, and usually of great width. The tissue composing it consists of large convex vesicles, rather flattened and much elongated in the direction of their growth, often presenting a pustulate appearance and distinctly visible, thus differing from the Russian *L. papillata*, in which the vesicles are smooth and indistinct. The number of rows between the outer wall and the inner mural investment varies, but the usual number is six. In two or three instances the septa approach the outer wall; but in other cases, and, in fact, in an overpowering majority of corallites, there is a large development of vesicular tissue, especially in the angles of the corallites. The inner mural investment, which usually forms the line of demarcation between the outer vesicular zone and the septal area in most species of *Lonsdaleia*, is very irregularly developed. In some instances, but not in the generality of the corallites, it is distinctly visible, but usually lacks the festoon or scalloped margin so characteristic of it in most of the British Carboniferous species.

The septal, or what would be usually called the intermediate area, McCoy's second area of vertical lamellæ, is of medium size, the septa starting in an irregular and ill-defined manner from the distal row of vesicular plates. They number from eighteen to twenty, and are all primary, careful examination having failed to detect the presence of intermediate and smaller radii. The septa are connected by irregularly placed and close-set tabulæ, but owing to the oblique direction of growth of the latter, they give rise when cut in cross-section to the appearance of dissepiments as if dividing the interseptal spaces into loculi. That this is not the case, however, is amply proved by vertical sections, although from their oblique direction the appearance of these tabulæ is very deceptive. The septa themselves are simple, fairly direct in their course, although here and there a little curved.

There is no columella or "complex axis" strictly speaking, but the surfaces of none of our specimens is sufficienlty perfect to show the natural condition of the septal area at its superior termination. But in a horizontal section (Pl. III, fig. 5) it becomes evident that the distal ends of some of the septa are very loosely twisted, or even only commingled, and hardly even united by any transverse plates, so that a middle

or columella zone can hardly be said to exist in this species. There certainly is no columella in the sense of *L. floriformis*, Flem., sp., *L. Bronni*, Ed. & H., or *L. papillata*, Fischer, and others.

More often than not the whole of the septa have been removed from the corallites by ordinary disintegration, leaving the centre as a pipe or circular hollow (Pl. III, fig. 2), on the sides of which the vertical fractured edges of the septa are quite visible. But in some cases the septal zone is preserved, when the want either of a simple or "complex" axis is quite apparent.

In a vertical section prepared for the microscope (Pl. III, figs. 3 and 4), the outer wall is very clearly shown as a thin white line. Equally plain is the vesicular outer zone, with its large vesicles obliquely placed in the direction of the coral's growth. It is against the innermost tier of these that the proximal ends of the septa lie, and in this case the "inner mural investment" becomes more apparent. The vesicles spring at first almost vertically from this line, and then curve outwards, overlapping one another, to the external wall. The interseptal tabulæ are equally well shown in a vertical section, but their oblique direction has already been commented on.

The rudimentary state of the columella, or "complex axis" at once separates *L. ? bipartita* from the European and Indian species. In the former and some of the latter, the columella is well developed. But in those Indian species in which this structure is defective, its place is taken by a true tabulated area, thus showing a departure to the genus *Thysanophyllum*, Nicholson and Thomson. This is "related to the genus *Lonsdaleia* . . . in the general form of the corallum, in the presence of an exterior vesicular zone of large cells, and in the possession of septa which have no connection with the outer wall. It is distinguished, however, by the fact that there is no true columella, and there is always a conspicuous central tabulate area uncovered, and exposed to view in the former; whilst in the latter, the centre of the calicular cavity is occupied by a prominent boss, and by the possession of a median columellarian line, which extends from the superior to the inferior extremity of the corallum, and is surrounded by convex vesicular tissue."

Our coral agrees with *Spongophyllum* in the highly vesicular or cystoid nature of the corallites, strongly resembling in this respect, *S. semiseptatum*, Schlüter, *S. elongatum*, Schlüter, and *S. Kunthi*, Schlüter.* It also resembles the last-named in its mode of growth. There is a further likeness in the absence of a columella, the delicate nature of the septa, and the method in which these advance to the centre of the corallites without twisting or uniting, as seen in *Spongophyllum elongatum*, Schlüter. On the other hand the new form has much more delicate but more distinct external walls than the species quoted above; there is a modified inner wall or "inner mural investment," and the septa are laterally united by a much larger

* Verhandl. Naturhist. Vereines preuss. Rheinlande u. Westfalens, 1881, xxxviii, heft 2, t. 5, f. 1, t. 7, f. 1 and 5.

quantity of dissepimental tissue than is found in *Spongophyllum*. Finally, in a vertical section of the latter there is not the same definite evidence of the septal zone that occurs in *Lonsdaleia* and our species. It must, however, be borne in mind that Schlüter's species do not in every way correspond with Edwards and Haime's type of their genus, viz., *Spongophyllum Sedgwickii*,* any more than does *L.? (Spongophyllum?) bipartita.* As interpreted by Schlüter, *Spongophyllum* closely approaches *Endophyllum*, with which, indeed, he appears in some measure to unite it. Now, it is manifest that in our *Lonsdaleia? bipartita*, we have a form intermediate between *Lonsdaleia* proper, *Spongophyllum*, and to some extent *Thysanophyllum*. Like the latter, it lacks a columella; but unlike Nicholson and Thomson's genus, it does not possess a "central tabulate area uncovered and exposed to view." It is interesting to note, in conclusion, that even Messrs. Edwards and Haime remark on the resemblance of the vesicular zone of *Spongophyllum* to that of *Lonsdaleia*.†

In the meantime, and until additional material is available for further study, I shall content myself by provisionally placing the present species in *Lonsdaleia*. It would have been an advantage to compare our fossil with Rominger's genus *Vesicularia*, but his work on the Michegan Corals is not available.

The specimens are from the Hume Wood Lead Mine, near Yass, and were presented to the Mining and Geological Museum by Mr. R. A. Barber.

V.—On the Occurrence of Tellurium in combination with Bismuth, from Norongo, near Captain's Flat, N.S.W.: by JOHN C. H. MINGAYE, F.C.S., Analyst and Assayer.

OBSERVING a peculiar reaction, which took place on the fusion of a supposed bismuth ore in cyanide of potassium for the estimation of the percentage of metallic bismuth, I undertook the following investigation as to the cause of the same.

On fusing the minerals the bismuth was left in the metallic state, the cyanide giving a rich purple colour, which deposited a black metallic powder on standing, the solution losing its colour.

As this reaction is peculiar to Tellurium I was induced to test for that element with the result that a large quantity was found present.

* Mon. Brit. Dev. Corals, 1853, t. 56, f. 2 a-e.
† Archiv. Mus. Hist. Nat., Paris, 1851, v., p. 425.

On treating some of the metallic powder with concentrated sulphuric acid it at once gave a purpled coloured solution, a characteristic test for tellurium, and it also answered to all other tests given for that metalloid.

The mineral was discovered at Norongo, about eight miles south of Captain's Flat, in a gossan lode about sixteen feet wide, through which runs the vein containing the mineral, the latter being six inches in width, and occurring at a depth of about two feet from the surface.

Three samples were received for assay, which I believe to be bulk samples, and found to yield as follows:—

No. 1.

Metallic Bismuth	16·90 per cent.
Tellurium	7·04 per cent.

Fine silver at the rate of 2oz. 3dwt. 13gr. per ton.
„ gold „ 3dwt. 6gr. per ton.

No. 2.

Metallic Bismuth	27·88 per cent.
Tellurium	10·42 per cent.

No gold or silver present.

No. 3.

Tellurium	19.3 per cent.

The mineral was associated with an earthy gossan, was steel-grey in colour, crystalline, and with a bright metallic lustre.

Through the kindness of Mr. R. Price I was supplied with specimens showing this mineral freely, as also other minerals, which I shall describe further on.

After much trouble I succeeded in detaching from the matrix sufficient of the mineral for analysis, and found it to be Tetradymite, or Telluric-Bismuth Ore, $Bi_2 Te_2 S$. An analysis gave as follows:—

Tetradymite (or Bismuth Telluride).

Metallic Bismuth..	59·66
Tellurium	33·16
Selenium	...
Sulphur	4·54
Iron...	·42*
Silica	·40*
	98.18

The above analysis corresponds with the formula given for the compound containing sulphur, $Bi_2 Te_2 S$. The Sp. Gr. is 7·381.

* Impurities.

Before the blow-pipe the mineral easily melted, coating the charcoal with a yellow and white incrustation, also giving a greenish-blue colour to the flame.

Telluric-Bismuth,* or Tetradymite, is stated to have been found in Virginia, Georgia, North Carolina, Cumberland (England), and Brazil, the tellurium sometimes being replaced by sulphur and selenium. The Sp. Gr. is given at 7·2 to 7·9, hardness, 1·2.

The Geological Surveyor-in-Charge, Mr. C. S. Wilkinson, drew my attention to a claret-red coloured mineral, which in places coated the Tetradymite. The mineral was found to contain tellurium, bismuth, iron, and water, and is a variety of Montanite.

Montanite, or bismuth tellurate, of a yellow colour, is often found associated with tetradymite, formed through the oxidation of that mineral, and is in reality a pseudomorph of the latter on which it forms a coating.

On examining a large quantity of specimens pieces were obtained which showed this mineral in a fair quantity, and from these I succeeded in detaching sufficient for a quantitative analysis.

The analysis gave as follows :—

Bismuth oxide ($Bi_2 O_3$)	50·68
Tellurous ,, ($Te O_3$)	27·65
Iron ,, ($Fe_2 O_3$)	14·38
Water	6·16
Gangue	1·00
	99·87

Before the blow-pipe the mineral gave the reactions for bismuth and tellurium, also giving the flame a greenish-blue colour. It was soluble in hydrochlorid acid.

A mean of several experiments gives the Sp. Gr. at 3·789. This brownish-red mineral is, as the analysis shows, a new variety of Montanite, and is in Mr. T. W. E. David's opinion pseudomorphous after iron pyrites.

In Professor Liversidge's work entitled "Minerals of New South Wales, &c.,"† tellurium is reported to occur at Bingera, County of Murchison; but no evidence is given in support of this statement.

* Watt's Dict. Chemistry, 1883, vol. v.
† 8vo., Sydney, 1888.

VI.—Description of the Physical Characters of Telluric-Bismuth Ores from Norongo, near Captain's Flat, New South Wales: by T. W. E. DAVID, B.A., F.G.S., Geological Surveyor.

THE specimens of Telluric-Bismuth Ores forwarded for examination from Norongo, near Captain's Flat, consist of lumps of irregular shape, from one inch to nine inches in diameter.

They are associated with an earthy, somewhat cellular gossan of a reddish-brown colour, and consisting of red and brown ferruginous earth, traversed by numerous thin veins of limonite, the secondary origin of which is evident from its stalactitic structure in places, and from the fact that it forms the lining of old cavities.

Small scales of a pale bronze grey micaceous mineral are plentifully distributed through the ochreous earth. They are much decomposed, and upon slight pressure fall into an ochreous powder. A little original quartz, showing cubical cavities, probably resulting from the decomposition of iron pyrites, occurs in the gossan in isolated patches.

The lumps of Telluric-Bismuth enclosed in the gossan show, on freshly-broken surfaces, a general concentric structure, due to the tetradymite having been incrusted with successive coats of decomposition minerals.

The outermost coat, from one-eighth to one-quarter of an inch thick is an earthy mineral the colour of yellow ochre, inclining to orange in places, and showing cubical cavities. Next beneath this telluri-bismuthic ochre is a layer of greenish yellow Montanite, having a somewhat streaky structure. In the second layer, and occupying former cubical cavities, are spots of dark brownish red montanite, from one-eighth to half-an-inch in diameter.

Next beneath the second layer, and forming the nucleus of a lump is a granular-crystalline steel grey mass of tetradymite.

The minerals in these ores may, therefore, be classed as follows:—

(1.) Tetradymite.

(2.) Montanite $\begin{cases} (a) \text{ Pale yellow variety.} \\ (b) \text{ Ferruginous dark brownish red variety.} \end{cases}$

(3) Telluri-bismuthic ochre.

The two first minerals may be further described as follows:—

1. TETRADYMITE occurs in granular crystalline masses, of a steel grey colour and bright metallic lustre.

Under the microscope the crystals are seen to have a very perfect basal cleavage, so that the mineral splits readily into very thin laminæ, over one hundred being visible in one crystal within a space of one-twentieth of an inch. Most of the crystals appear to be tabular. The orientation of the crystals in each mass is tolerably uniform, and the planes of basal cleavage lying in consequence principally in one line, the mass has a tendency to split readily along these planes, which accounts for the streaky appearance of the montanite surrounding the tetradymite.

The *hardness* is about $1\frac{3}{4}$, the mineral being unaffected by talc, easily scratched with calcite, and difficulty scratched with selenite. The laminæ are flexible.

The *streak* is black and shining, much like that of graphite.

2. MONTANITE *(a), Pale greenish-yellow variety.*

This mineral encrusts the tetradymite, and does not show any crystalline structure. Green tints are observable in this variety wherever the particles of half-decomposed tetradymite become abundant, the green being due to the steel-grey tetradymite showing through the yellow coating of montanite.

The *lustre* varies from dull earthy to waxy. The *hardness* is about $1\frac{1}{2}$.

(b.) Ferruginous dark brownish red variety.

This variety occurs in cubical pseudomorphs, single or aggregated, and $\frac{1}{8}$ inch in diameter.

The *colour* is dark brownish red, excepting on thin edges, where the mineral is semi-transparent and of a deep claret colour. The *streak* is of a red ochreous colour. The mineral is brittle, and has an uneven, irregular fracture.

The *hardness* is about 3, but appears to vary considerably in the different specimens, as calcite will just scratch some, but is itself scratched by others. From the roughly cubical shape of this mineral, taken into conjunction with the existence of numerous cubical cavities, like those left after the decomposition of iron pyrites in the telluri-bismuthic ochre and gossan, it appears to me highly probable that this variety of montanite is psuedomorphous after iron pyrites, and the analysis proves that the dark brownish red colour is due to the combination of iron with the montanite.

It may therefore be described provisionally as ferruginous variety of montanite, pseudomorphous after iron pyrites.

VII.—Sketch of Columnar Basalt on the Horton River, near Lindsay Station.

[Plate IV.]

THE accompanying sketch of the Horton River Falls, situated about one and a half miles from the homestead of the Messrs. Sawers and Wilson's Lindsay Station, was made by Mr. Henry W. Powell, Forest Ranger, Gunnedah, who has forwarded it to the Department with the following interesting description.

The Horton River, for some distance above the falls, runs over the tops of basaltic columns, giving the bed of the stream and the bank on the east side the appearance of a large pavement. The stream then empties itself into a basin about fifty yards across and twenty or thirty long, in the shape of a horseshoe, the sides of which are formed of these columns.

The water pours over in several jets between the different columns, which measure twenty feet in height. The columns are mostly five-sided, though some have four and some six sides, and measure five feet and upwards in diameter; they are horizontally jointed, and appear as though they had been built up in courses.

Part of the basin is heaped up with fragments of these columns which have a smooth surface where the joint has been broken.

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Vol. 1.] 1889. [Part 2.

VIII.—Notes on the Mineral Resources of New South Wales, as represented at the Melbourne Centennial International Exhibition of 1888; by J. E. Carne, Curator, Mining and Geological Museum, Department of Mines, Sydney.

I.—Introduction.

The Commission appointed to secure the proper representation of New South Wales at the above Exhibition, in accordance with the practice of previous Commissions, requested the Honorable the Minister for Mines to undertake, through his Department, the preparation of a thoroughly representative exhibit of the mineral resources of the Colony; also to classify and prepare all private exhibits of a like nature, and to arrange the whole in the space set apart by the Executive Commissioner as a Mineral Court. This request having been approved, the necessary steps were taken to ensure a display worthy of the reputation already gained by New South Wales as a varied and extensive mineral-producing country.

Having been instructed to devote myself to the work, after inspection of the space set apart for the above purpose, a general plan of arrangement was designed, which, meeting with approval, I was authorized to carry out.

In the following notes I have endeavoured to present a concise account of the exhibits thus brought together and arranged, and whilst avoiding technical descriptions, to furnish such information as could be gleaned from publications of the

Department of Mines and other reliable sources, as to the nature, occurrence, and yield of the deposits from which they were obtained, deeming that this presented in convenient form would be of service and value to those interested in our mineral resources.

II.—General Arrangement of the Court.

I preface the detail description by a brief *resumé* of the general arrangement.

The Mineral Court was situated directly on the right-hand of the Avenue of Nations upon entering from the main or permanent hall. It was nearly square, having a frontage of 110 feet to the above Avenue, by a depth of 106 feet, and embraced an area of 11,660 square feet, being bounded on two sides by main avenues, on another by a wall, and on the remaining side by the wool exhibits of the Colonies. It was very compact, and so situated with regard to surrounding exhibits that its contents were thrown into greater relief by contrast. Upon entering the Avenue of Nations from the Main Hall, the object that arrested the view was the handsome silvered obelisk erected by the Broken Hill Proprietary Company; but the first exhibit was a model of portions of the Jenolan Caves, with an imposing entrance—constructed in imitation of the Grand Arch—prepared by direction of the Executive Commissioner, and planned and admirably carried out by Mr. Noonan. Near the entrance, in an upright glass show-case, was an exhibit of stalactites, stalagmites, and crystals from the same caves, collected and arranged very naturally by the keeper, Mr. J. Wilson, by instructions from the Minister for Mines. The visitor was thus enabled, after viewing man's handiwork in imitation, to turn and view nature's in reality. It is, perhaps, well to state that the beautiful specimens in this case did not represent the spoil of a Vandalism only too common with regard to Nature's treasures, but were the proceeds of explorations of intricate and almost inaccessible holes and passages, impassable to the ordinary visitor.

The next object on the frontage was an octagonal pyramid of copper ingots surmounting a base of copper ores from various mines. Then came the artistic obelisk of the Broken Hill Proprietary above alluded to. It consisted of an octagonal base about eleven feet in diameter and three feet three inches high, faced with rough blocks of stone from the outcrop and from different levels; on this rested eight slanting show-cases containing samples of the various ores—to be described further on—from this height sprang a handsome, ornamented column, capped by a large casting of Atlas supporting the world, reaching to a height of thirty-three feet three inches, with a bulk of 577 cubic feet, and thus representing the total quantity of silver produced by the mine since smelting was begun in May, 1886, to the time of designing in June, 1888, viz.: 5,508,836 ounces, or 166 tons, of fine silver.

Next to this was a huge pile of auriferous quartz from the Kurrajong Gold Mine, Adelong; then a porch, or entrance to the main portion of the Court. Next to this another large pyramid of ore from the White Rock Silver Mine, Fairfield; and then at the extreme northern end of the Court, a massive square-based pyramidal trophy of copper ingots and ore, from the Burraga Mine, about fifty miles from Bathurst.

The Court was divided into bays by lines of supporting pillars, running at right angles from the Avenue of Nations. The first bay on the south was devoted principally to coal and shale exhibits, which were arranged on either side of a broad central passage traversing its length, at the end of this, and opposite to the entrance, was placed a large trophy of coal blocks; on the panels which enclosed the angular spaces of the trophy, were given the names of the principal collieries at work upon the coal seams described on the upright panels at the centre of the angles; at the base of the angular spaces were show-cases containing exhibits of coke. This exhibit was designed primarily to draw attention to the particulars thus displayed.

On the right hand upon entering the bay from the Avenue was a handsome show-case, standing on a raised platform, containing a most attractive exhibit of the products of the Australian Kerosene Oil and Mineral Company's shale, a pile of which was shown at each corner of the platform.

On the wall space, which formed the southern side of this bay, were arranged the mining and geological maps, sections, &c., of the Department of Mines. The next bay, which was entered by the porch before-mentioned, was devoted principally to metalliferous exhibits. Directly upon entering, the visitor was confronted with a massive coal and stone triple archway, spanning the bay at about two-thirds of the depth of the Court from the entrance. The two centre pillars were four feet by four feet by thirteen feet six inches high; and were formed of twelve feet of coal, resting on one foot of sandstone from underneath the coal-seam at Waratah, and capped by six inches of sandstone from the upper beds of the coal series in New South Wales (Hawkesbury Series), the coal being from the Burwood Colliery, near Newcastle, and the latter sandstone from R. Saunders' Pyrmont Quarries, Sydney. The coal pillars represented about the average working thickness of the Borehole seam. The two outer pillars, of the same height and depth, but one foot narrower, were constructed of rough-dressed sandstone, also from Pyrmont Quarries.

The superstructure of the archway bore the following inscription, in silver letters on a black ground:—"Mineral Court of New South Wales."

"Minerals raised in New South Wales to 31st December, 1887—total value, £72,938,124 18s.*

Mineral	Quantity	Value £	s.	d.
Gold	9,885,094·25 oz.	36,863,717	9	1
Silver	2,923,037·62 oz.	1,806,349	0	0
Silver-lead — Metal	13,231 tons 1 cwt. 1 qr.			
Silver-lead — Ore and Regulus	15,894 ,, 14 cwt. 2 qr. 7lb.			
Coal	39,892,861·97 ,,	19,698,831	15	5
Shale	481,252 ,,	1,083,174	5	0
Iron	36,228 ,, 15 cwt. 0 qr. 6 lb.	265,464	14	6
Tin — Ingots	85,078 ,, 6 ,, 0 ,,	7,927,876	0	0
Tin — Ore and Regulus	16,671 ,, 13 ,, 0 ,,			
Copper — Ingots	79,131 ,, 18 ,,	5,163,352	0	0
Copper — Ore and Regulus	3,760 ,, 4 ,, 2 ,,			
Antimony — Metal	475 ,, 13 ,, 1 ,,	67,239	0	0
Antimony — Ore and Regulus	25 ,, 4 ,, 0 ,,			
Bismuth	104 ,, 18 ,,	20,575	14	0
Asbestus	25 ,, 4 ,,	488	0	0
Sundry Minerals		41,057	0	0"

Down the centre of this bay ran a broad passage, as far as the Wool Trophy on the east. On either side of it were massive trophies of ores, alternating with show-cases containing hand specimens.

In the portion of the third bay embraced by the Mineral Court, and fronting the east and west avenue, arranged on six stands, and in four cases, was the large and valuable collection of timber specimens, barks, fibres, gums, resins, seeds, etc., exhibited by the Minister for Mines. In this space also was arranged in six show-cases, a collection of fossils from the principal sedimentary formations of the Colony, also exhibited by the Minister for Mines.

In the arrangement of the Court an endeavour was made to place the different groups of ores together; but in some instances this was prevented by the late, or non-arrival of exhibits intended for certain positions, which had to be filled with ores from another group. If, therefore, any exhibits were not as advantageously placed as could be desired, it was owing to late arrival; and it behoves intending exhibitors on such occasions, for the advantage alike of the exhibits and the Court, to dispatch them early.

Exception has been taken to the meagre information on the labels attached to certain exhibits, both as to variety and yield, of the ores forming them; such, in certain cases, was undoubtedly true; but the fault did not rest with those engaged in the work of arrangement. In each case the fullest information was solicited; this particularly refers to occurrence, extent, and yield of the deposits represented. As regards non-classification, it can be reasonably urged that exhibits arriving during the rush of hurried arrangement in the Court, could not be other than roughly classed into groups. Again, the main idea in connection with many exhibits, was massiveness, to separate and classify the different varieties in a large pile of ore would require unreasonable space. In the general collections of

* Compiled from the Annual Report, 1887, of Mr. Harrie Wood, Under Secretary for Mines.

different ores exhibited by the Minister for Mines, nearly, if not all, of the varieties could be seen properly classified and arranged. In the following notes and compilations I have endeavoured to remedy the defect as regards the information concerning the nature, occurrence, and yield of the ores exhibited, where no particulars are given none have been available.

III.—Gold.

Taking the metals in the order of their respective values (of output), gold occupies the premier position,—The weight of gold obtained to the end of 1887 was 9,885,092 ounces, of the value of £36,863,716. Except in some few localities, quartz veins have not been worked to a great depth. The deepest mines in the Colony are at Adelong, where payable quartz has been raised from a depth of over 1,000 feet. Alluvial lands have in some instances been worked to a depth of 200 feet, and there are the strongest indications of deep leads in various parts where no attempt has been made to work them. Gold-mining, as hitherto carried on, has been principally confined to the working of river beds and shallow alluvial claims and deep leads. Extensive areas of country are known to be auriferous, and it is believed that there will be ample scope for the remunerative employment of a large population in both alluvial and quartz mining. The poor success which has often attended the working of quartz veins is largely attributable to ill-judged speculation, inexperience, and the absence of proper ore-separating and other mining appliances.

The approximate area included within the proclaimed gold-fields is 91,800 square miles; but, from the geological formation of the country, it is believed that the area in which payable gold deposits will be found will be greater than that now stated. From some of the reefs at Hill End crushings gave at the rate of from 30 to 2,100 ounces of gold per ton. It is known that much gold passes away in the tailings, and is lost in consequence of the imperfect appliances at present employed for the treatment of auriferous pyrites.

The Minister for Mines had a splendid exhibit of reef and alluvial gold; two specimens of the former, obtained from a depth of 90 feet at the Mother Shipton Reef, Temora, were of special interest, the largest was estimated, by specific gravity test, to contain 258·33 oz. of fine gold in about 60 oz. of white quartz; the other was estimated by the same test to contain 41·53 oz. of gold in about 90 oz. of quartz. The following samples were also worthy of note:—Gold in ferruginous quartz from Solferino; forming a thin vein in quartz from Bingera; in serpentine from Lucknow; in calcite from Ti-tree, Oakey Creek, Barraba District. Particularly noticeable amongst the specimens of alluvial gold was the handsome "Maitland Bar Nugget," obtained from a depth of five feet, at Hargraves, which was estimated by specific gravity test to contain 313·093 oz. of fine gold, of the value of

£1,236 14s. 1d., the gross weight being 344·7 oz. Another nugget from Woods' Flat, near Cowra, weighed 42 oz. 17 dwt. 5 gr., of the value of £168 5s. 5d; one side of this specimen, which has been protected from attrition by a ferruginous clayey covering, presents a nest of crystal facets. Two small nuggets were shown from Trunkey and the Turon. Forty-four samples of alluvial gold from the undermentioned localities were also shown, and the assay report of each sample was given, as supplied by the Royal Mint, Sydney :—

Locality.	Specific gravity.	Loss per cent. in melting.	Assay Report. Gold in 10,000 parts.	Assay Report. Silver in 1,000 parts.	Gross value per oz. £ s. d.
Tenterfield	15·89	2·733	·8905	·100	3 13 11
Mudgee	16·89	1·713	·9370	·055	3 18 5
Tibooburra	18·33	·423	·9735	·020	4 2 4
Uralla	17·76	1·215	·9550	·040	4 0 3
Tumbarumba	15·98	2·955	·9460	·045	3 18 1
Bathurst	16·78	2·033	·8865	·080	3 14 0
Forbes	15·47	2·647	·9215	·075	3 16 5
Hill End	16·44	2·663	·9445	·045	3 18 2
Sofala	16·71	1·848	·9265	·070	3 17 5
Kiandra	15·15	3·115	·9240	·070	3 16 3
Nundle	15·00	2·642	·9220	·070	3 16 5
Bingara	14·54	5·137	·8995	·090	3 12 9
Tamworth	15·94	1·716	·9355	·060	3 18 3
Copeland	14·69	3·748	·9000	·090	3 13 10
Nerrigundah	17·75	1·395	·9825	·010	4 2 4
Murrumburrah	17·06	1·906	·9470	·045	3 19 0
Glen Innes	17·19	1·535	·9435	·050	3 19 0
Ironbarks	16·29	2·420	·9420	·055	3 18 3
Orange	16·29	2·188	·9290	·065	3 17 5
Windeyer	18·39	·995	·9550	·040	4 0 5
Temora	16·71	2·166	·9575	·030	3 19 7
Rocky River	16·70	1·423	·8760	·115	3 13 9
Adelong	17·18	1·953	·9470	·045	3 19 0
Tambaroora	17·10	1·522	·9335	·060	3 18 3
Braidwood	16·73	2·330	·9455	·045	3 18 7

Mr. M. Isaacsohn, of Nundle, exhibited a number of very beautiful specimens of crystallized gold from Bowling Alley Point, Peel River, some of the gold crystals being associated with clear quartz crystals, both having been deposited from solution in a cavity in the veinstone ; the same exhibitor also showed a number of samples of alluvial gold.

Professor Liversidge exhibited interesting specimens of crystallized gold from Gulgong, Louisa Creek, Orange, Lion Reef (Grafton), and Mudgee ; moss-gold obtained from mispickel, Lucknow ; and gold in calcite, dolomite, serpentine, pyrites, and arsenic.

The Minister for Mines exhibited a collection of auriferous ores, comprising auriferous binary granite, from the 1,050 feet level in the Great Victoria Mine, Adelong ; auriferous lode-stuff (gneiss), from the 1,000 feet level, in the same

mine; auriferous quartz, with pyrites, from the 770 and 975 feet levels; quartz showing free gold from the Kurrajong Mine, Adelong; lodestuff (binary granite), with free gold and pyrites, from the Challenger Mine.

The following particulars regarding the Great Victoria, the deepest mine in New South Wales, may be of interest; a trial crushing from it was made with a view of proving the claim to a Government reward for a payable reef at depth exceeding 1,000 feet.

"The quartz crushed for the recent trial came from the south shaft, at a depth of about 1,030 feet, which level is equal to 1,067 feet below that of the surface at the North Shaft, as the latter is 37 feet above that of the South Shaft, owing to the slope of the hill. The reef at the deepest level attained, viz., 1,056 feet, presents the same features that it does at the higher levels . . . . it occurs in a dark greenish schist which varies in width from about 2 to 10 feet, and it is bounded on both sides by well defined walls of hard quartzose granite containing black mica The quartz reef is sometimes over 12 inches thick, at others it makes into several veins accompanied by numerous thread-like veins of gold-bearing quartz interlaminated with schist, so that in places nearly the whole width of the schist or channel of the reef is taken out for crushing. Such is the general character of the veinstuff from the surface down to the lowest level. Both the schist and the quartz are highly impregnated with pyrites. Occasionally "horses" of granite make into the schist. The reef is nearly vertical, sometimes underlaying slightly to the east, at others to the west, but the general underlay is easterly; the strike of the reef is N. 10° W." *

The Kurrajong Gold-mining Company, Adelong, exhibited ten tons of auriferous pyritous quartz, in which zincblende occurred sparingly, the stone yielding the best returns where it was present. The remarks quoted from the Report of Mr. C. S. Wilkinson, Government Geologist, on the Great Victoria Mine, in the same field, will apply as regards the general character and features of the reef, equally well to this mine; as also to the Donkey Hill stone from the same locality.

From Fairfield, New England, were shown samples of auriferous ferruginous quartz from Scott's, Rowan's, Carmichael's, Parnell's, Bourke's, Dempsey's, and others' claims; auriferous quartz with zincblende and pyrites from Strous and Party's claim, auriferous lode-stuff with zincblende, pyrites, and blue and green carbonates of copper from Fogwell and Party's claim. One sample from this locality shows an assay value of 5 oz. 8½ dwt. of gold per ton. Mr. Geological-Surveyor David, who examined this field, states that:—

"Gold occurs here in numbers of thin veins of quartz traversing a felsite breccia, and the latter also is auriferous for several feet on either side of the quartz veins. Diorite occurs about a quarter of a mile S.E. from the Prospectors;

* Government Geologist's Report—Annual Report, Department of Mines, 1883, p. 152.

and in Hynde's shaft, on the south side of the Grafton Road, adjoining the Prospectors, a dyke of quartzose diorite rock was cut in the West Drive. The dyke strikes N.W. The felsite breccia is variable in character. At a short distance from the ore deposits it is very hard, and consists of angular fragments of opaque whitish-grey felsite from a ¼ inch to 1 foot in diameter, set in a quartzose or felsitic base. In other places, as at Harkness and Party's claim, a quarter of a mile N.N.E. from the Prospectors, the breccia is more dioritic. In the vicinity of the ore deposit, the breccia is very much decomposed, being comparatively soft to a depth of 35 feet from the surface, and is of a prevailing reddish purple colour. . . . the veins are very irregular in strike and dip ; and the manner in which the veinstone in most cases passes gradually into the country rock without the intervention of defined walls precludes them from being classed with those fissure veins, in which there is evidence of considerable vertical displacement. They rather resemble shrinkage cracks which have been filled with auriferous metallic sulphides and quartz. The veins at the top of Mount Carrington will prove auriferous to a depth of at least 300 feet, as is proved by natural sections. At this depth the veins will be better defined, but probably more contracted, and the country will become harder. There are two kinds of ore to be treated—(1) the oxides, and (2) the sulphides. The latter are by far the most important, as the former, on the average, do not extend for more than 30 feet below the surface. The oxidized ores in such veins as Bourke's will certainly pay well for working down to the water level.

"As regards the main question as to whether the ores can be worked to advantage below water level, the yield of the sulphides from the veins lying at the base of Mount Carrington is so small (4 dwt., according to assay) that it will not leave sufficient margin to pay for the extraction of the gold from the sulphides of iron, zinc, and copper, unless, as pointed out, the sulphides in the ores be concentrated by machinery. At the higher levels, near the top of Mount Carrington, the veins, as a rule, are wider, and there is a great body of stone which the returns by assay have shown to yield from 4 dwt. up to 2 oz. Experience alone will prove whether a large body of easily won stone with this yield can be worked profitably when it contains ores so difficult of treatment as sulphides of zinc and copper and iron pyrites." *

Auriferous ferruginous quartz was shown from the Confidence Gold-mine, King's Plains. Of the occurrence of the latter the Government Geologist states :—

"The quartz veins, from an inch to 4 feet thick,† are found to intersect in an irregular course, but generally about E. & W., a soft ferruginous siliceous and felspathic dyke, which is from 15 to 45 feet wide, and runs north and south. Gold occurs both in the dyke and in the quartz veins, and the whole dyke mass with the

* Annual Report, Department of Mines, New South Wales, 1886, p. 159.
† Annual Report, Department of Mines, New South Wales, 1886, p. 134.

veins, is taken out, and put through the battery. I was informed that 7,160 tons crushed had yielded at the rate of about 3 dwt. per ton. The dyke, being soft, is easily worked."

From Copper Hill, near Molong, was shown an exhibit of auriferous quartz. According to the report* of the Government Geologist, Copper Hill is a huge mass of felsite with hornblende porphyry in places, and is traversed by numerous lodes or dykes of porous ferruginous quartz. Auriferous stibnite (sulphide of antimony) from the Eleanora Mine, Hillgrove, sixteen miles east of Armidale, was exhibited in bulk by the Minister for Mines. Of this interesting deposit, the Government Geologist reports:—†

"The country generally consists of rocky hills of no considerable height, but Baker's Creek, which flows through it in a southerly direction, suddenly descends into a large precipitous ravine, called 'The Falls,' which is about 1,600 feet in depth. This abrupt valley, which, like that of the Gara Falls, opens into another of greater magnitude, is a splendid instance of the effects of the denuding agencies which have eroded the slopes of the Great Dividing Range.

"The formations of the country are granite and metamorphosed sedimentary rocks, probably of Devonian age. The antimony reefs crop out in places not only on the hills, but also at various levels on both sides of the deep valley. It traverses altered slates and dips E. 40 N. at an angle of 80°. The reef consists of dark blue siliceous slate crossed by a net-work of quartz veins which give it a brecciated appearance. A granite dyke accompanies the reef, and generally divides it in two. Both the dyke and the reef vary in thickness; thus in the Eleanora Company's claims, the hanging-wall reef is from 6 inches to 18 inches thick, the dyke to 5 feet, and the foot-wall reefs from 1 to 4 feet. Oxide and sulphide of antimony (stibnite) occur in irregular bunches, and also finely disseminated through the reefs, but they are absent in places. Gold is sometimes plainly visible in the quartz."

Auriferous pyritous quartz from Black Range, near Albury, yielding 4 oz. 7 dwt. gold per ton, at a depth of forty feet. Auriferous lode-stuff, consisting of serpentine and calcite, with mispickel and metallic antimony from the New Reform Gold-mining Company, Lucknow, near Orange. The Government Geologist, in a progress report, has the following description of the occurrence of the ore:—

"The reefs occur at the junction of serpentine and hornblende felsite, the latter in places passes into diorite.‡ Along this line of junction is what the miners term the "lode," which, at the surface, is a fissure 6 feet or more in width, extending in a direction S. 50° E., for a distance of 50 chains. It is filled with a red sandy ferruginous clay, containing hard siliceous accretions of irregular shape, locally termed "clinkers." This lode dips to the north-east at an angle of about 65°, though in some places it is nearly vertical.

* Annual Report, Department of Mines, New South Wales, 1885, p. 130.
† Annual Report, Department of Mines, New South Wales, 1883, p. 153.
‡ Annual Report, Department of Mines, New South Wales, 1881, p. 134.

The hornblendic felsite forms the foot-wall, and the serpentine the hanging wall. In the felsite, at varying distances along the lode, are quartz veins, from a few inches to 6 ft. thick, coming in from the west and abutting against the lodes, which they appear to follow down, and form irregular quartz "pipes" or "shoots," dipping diagonally along the lode towards the east. These veins have only been found to contain payable gold where they occur in the lode and form shoots.

The vein stuff consists of quartz, calcite, felsitic rock, and serpentine, with veins and irregular masses of arsenical iron pyrites disseminated through the mass, which assumes a serpentinous character as it approaches the hanging wall of serpentine, and in this part of the vein occurs the great portion of the rich gold-bearing arsenical pyrites."

Mr. H. W. Newman, manager of the mine, gives the following particulars regarding this mine :—

"It has been worked from the grass to 380 feet slope,* at which level highly satisfactory results daily occur. . . . The vein is 35 feet long, and averages 6 feet wide, and contains three grades of ore, which are shipped monthly to Messrs. Johnson, Maten, & Co., of Swansea. The Reform Co. make four samples of their material: First comes the bulk ore, which consists of the best stone containing pyrites, picked by hand, and sent away in its natural state, which yields from 60 to 80 oz. of gold and many ounces of silver per ton; sometimes the yield is even double what I have quoted, but, as an average, I am about it. Next comes No. 1 crushed ore, the free gold being extracted by the battery process; this ore yields from 30 to 40 oz. per ton, the yield depending entirely upon the separation of the sand from the ore, but it is found judicious, as a rule, to send the ore a little crude, as it pays best. Then there is No. 2 crushed ore; this is obtained from the refuse of No. 1, and returns, according to its cleanliness, from 15 to 20 oz. per ton. And lastly comes the refuse ore, obtained from the various strainings, which is called No. 3; this stuff returns from 2 to 12 oz. per ton."

Auriferous siliceous lode-stuff, with trace of carbonate of copper, and showing free gold was shown from Brown's Creek Mine, near Blayney. The following particulars of this interesting deposit are given in the Government Geologist's Progress Report, 1881 :—

"Brown's Creek Gold Mine is situated on the west side of Cowriga Creek, six miles west from Blayney.† The deposit which is being worked is a very remarkable one. It consists of a ferruginous breccia, containing siliceous accretions, or 'clinkers,' and fills a huge fissure, which is in places 150 feet wide, in diorite. It has been formerly worked by a large open excavation about 250 yards in length, but now the auriferous lode-stuff is raised from a shaft sunk close to the crushing

* Newman.—Extracts and Reports, Lucknow or Wentworth Gold Field, 1888, p. 5.
† Annual Report, Department of Mines, New South Wales, 1881, p. 131.

plant. The lode-stuff yields at the rate of about 3 dwt. per ton. The gold is very fine, and occurs not only in the softer portion of the lode, but also in the hard flinty accretions, and I believe it has been formed from a thermal solution permeating the lode. Some of the accretions are stained with green silicates and carbonates of copper."

Mr. T. W. Horton, jun., of Drake, New England, exhibited samples from the interesting auriferous granite deposits at Poverty Point, Timbarra, in the New England District. Where the granite is auriferous it has a talcose structure. Specimens of steatite, with gold freely visible, have been obtained from this locality. The following is extracted from Mr. Horton's description of its occurrence:— *

"The alluvial gold was first discovered by Mr. Dalton (who was afterwards appointed a Gold Commissioner) on M'Leod's Creek. The whole creek proved to be extremely rich, from its rise in the gold-bearing granite formation on the table-land top to its confluence with the Rocky or Timbarra River.

"This table-land top is about the highest portion of the coast range which bounds the Clarence River watershed on this portion of the field. It is the head of M'Leod's Creek, which takes a very erratic course through the mountains (easterly) to its junction with the Rocky River. It is also the head of the Sandy Creek, a main tributary of the Cataract River, running south. It is also the head of innumerable little gullies, all rich in gold, and all radiating from this centre, down the eastern fall into M'Leod's Creek, and down the western side of the range into Sandy Creek.

"The fall into M'Leod's Creek is very precipitous, and each of these little gullies carries its own distinct sample of gold to the junction, and the main creek bed is generally charged with the sample for a few yards below each junction, when the next gully deposits another sample. These samples are all of the same value, but vary in form and fineness. The heads of Sandy Creek and its tributaries were all extremely rich, but the country is flatter, so the gold did not travel far from its source in that direction.

"It was on this table-land top the first gold-bearing granite was found. It here forms a kind of table-land or broad rugged saddle between the heads of the two above-named creeks. The surface soil was first sluiced off to a depth of 4 to 5 feet, on to the hard granite rock. In a year or two afterwards, it was found that the weather had decomposed this rock to a depth of a foot or two; this was again cleaned off to the hard rock and sluiced, and this process has been repeated periodically during the past twenty years.

"From this point, continuing along the range south, we come to Donald Gray's, a remarkable talcose deposit, still on the highest abutment of the edge of the range, overlooking M'Leod's Creek, the Rocky River, Tabulum, and the

* Letter received from Mr. T. W. Horton, junr.

Richmond ranges, filling three narrow precipitous channels in the granite, and it appears to have been erupted at different periods. Some of the lower levels are impregnated throughout with iron and arsenical pyrites, others with nodules up to 3 inches in diameter. Many other deposits contain no pyrites; they vary from a hard gritty sandstone-like rock to a fine white kaolin clay, which is always very rich in gold. All the pyrites-bearing rock contains gold and silver.

"In some of the beds the pyrites are decomposed, giving the whole rock a reddish tinge; in others, the pyrites nodules are decomposed, without staining the country rock, forming what the miners call 'clinkers,' which are often extremely rich in gold. The deposit yielded the original discoverers 1,000 oz. of gold by hand-crushing and cradling.

"Continuing about 4 miles further along the range, we find the "tin swamp." Here in the swamps and gullies are alluvial deposits of ruby tin, associated with wolfram, manganese, tourmaline, and a little gold; but not payable.

"Six miles further south brings us to Poverty Point and the Great Sluicing Hill Gold-mining Company's claim. This is situated at the extreme end of the range, where it is cut off by the deep channel of the Rocky River. The claim is only 3 miles from the river, but 2,300 feet above the level of the river bed. The samples exhibited came from this locality. The original holders, ordinary sluicers, found gold in the grass roots all over the surface of the hill. Being at such a great elevation, they could only command the water-shed from the few tops of mountains standing at a higher elevation, and only got this under great difficulties. The result was that for many years they had never sufficient water to sluice for more than thirteen weeks in the year, and they regularly realized about £2,500 worth of gold per man per year. Some of the original holders have been working on the ground about thirty years, and are there still.

"The deposit has the appearance of alternate vertical belts of hard and soft granite, terminating abruptly at its southern end against a large vertical porphyritic dyke. The softer portions of the deposit have been sluiced away to an average depth of 40 feet by 40 feet wide, when the walls and bottom rocks become so hard that the action of the water cannot break up the particles of rock finely enough to liberate the gold, which is of an extremely fine nature: so fine that I have washed good prospects of gold from small tufts of moss and fine grass roots growing on the banks and boulders in the water-course, 5 miles below the workings. The gold has been carried down either in suspension in the water or enclosed in fine particles of sand, which had gradually worn away as they travelled down the range. A remarkable feature in the formation is that the whole of the auriferous granite formation, as well as the barren granite on either side, is traversed by three small smoky quartz veins, containing molybdenite and a little bismuth, and are rich in gold not only in the auriferous but in the barren country

on either side, while the auriferous rock is much richer in close proximity to the veins than it is throughout the entire mass. A number of immensely large granite boulders are seen about the surface, some embedded, others resting on the surface, others standing up, just balanced, on the most elevated points of the range, giving a splendid illustration of the denudation of the mountain range and of the liberation of the free alluvial gold. In the workings occasionally, vughs are found near the veins, lined with quartz crystals, set in well-formed white crystals of orthoclase.

"Several other deposits of this same granite formation occur in the neighbourhood on a much larger scale, which, although not sufficiently rich to pay for working, have, by the slow process of denudation during past ages, liberated sufficient gold to make the creeks and gullies leading from them exceedingly rich.

"In addition to the large deposits of auriferous rocks above described, greisen and dioritic dykes are occasionally met with, containing gold either free or in combination with pyrites, bismuth, and molybdenite. They have no defined walls or regular strike through the country; but sufficient work has not yet been done upon any of them to determine their structure or value.

"The auriferous granite differs from the ordinary country rock of the district in a few minor points. In the auriferous granite, the particles of quartz composing it have a smoky stain, and occasionally large, well-formed crystals of orthoclase are met with, say one in a cubic foot, while in the ordinary granite the quartz particles are of a white or greyish colour. The felspar in both rocks is in the same form, but varying in colour from white to all shades of red.

"In the country rocks the orthoclase crystals are not met with except in dykes, but they occur abundantly in the granite on the river (say) 2,000 feet below, with large quantities of titanic and magnetic iron. The quartz particles here are white, and carry no gold. Some very nice specimens of oligoclase are also found in the dykes here.

"I need not give you the history of the failure of the company who attempted to 'sluice' the hard granite mountain away, or the result of their late attempt to crush the mountain with a small plant, and a short supply of water; but I can safely say that there are millions of tons of stone that will yield from 2½ to 3 dwt. of free gold per ton, and I see nothing to prevent it becoming a good continuous dividend-paying property for an unlimited period, providing a sufficiently extensive plant was supplied.

"Statistics show that the Timbarra gold escort returns, from 1859 to 1866 inclusive, amounted to 71,058 oz. of gold; and I know that large quantities during this time went down by private hands, and since that date, during the past twenty-eight years the field has been continuously worked by Chinese and Europeans."

The Great Red Rock Gold-mining Company exhibited auriferous lode-stuff from the Fairfield Gold-field. The general characteristics of the reefs in this field have already been quoted from Mr. Geological-Surveyor David's Report (Annual Report, Department of Mines, 1886).

The Mining Registrar of the Fairfield division of the New England mining district has the following notice of the Red Rock Mine)*:—" At Red Rock, about 8 miles N.W. from Fairfield, the gold is found in gossan stone with quartz; it occurs not in veins or reefs, but in great masses. The average yield is estimated at 5 to 15 dwt. per ton. The Red Rock Company obtain their stone from an open cut or quarry in the mountain; the face is 25 to 30 feet wide, and the depth of the cutting is 20 feet. . . . The last crushing yielded 8 to 10 dwt. per ton. . . The stone is said to be practically inexhaustible, and it is estimated that 3 dwt. per ton will pay for working."

Auriferous quartz, with sulphide of antimony, was exhibited from the Razorback Gold and Antimony Mines, eighteen miles from Capertee. Of this reef the Government Geologist reports †:—" At Razorback an auriferous quartz reef, containing iron pyrites and sulphide of antimony, traverses black slate country. It occurs like the Eleanora Mine, near Armidale, with a trap dyke, and varies in thickness up to 3 feet 6 inches, dipping W. 25° S., at an angle of 1 in 6. As it follows the dyke it will probably be permanent in depth."

A trophy of auriferous quartz was shown from the Baker's Creek Gold-mine, Hillgrove, near Armidale. The veinstone is a greyish-blue quartz, slightly brecciated in places by the inclusion of fragments of black slate, and showing a casing of a similar slate; it is very free from pyrites. A little sulphide of antimony is present. The gold is freely visible, penetrating the stone, and very evenly disseminated through its entire thickness. The exhibitors had a number of specimens taken at random from the trophy cut and smoothed, and a magnifying glass attached to the stand, so that observers could see the richness of the stone. A recent crushing of 200 tons yielded 3,007 oz. of gold. Since the closing of the Exhibition this exhibit, weighing a little under 15 cwts., yielded within 2 dwts. of 55 oz. of fine gold.

The Golden Gully Gold-mining Company, Ironbarks, exhibited a very interesting suite of specimens, showing gold associated with mispickel (arsenical pyrites) in quartz and calcite. Some of the oxidized specimens show a concretionary nodular character, and have evidently resulted from the decomposition of pyrites. These samples contain a considerable amount of gold.

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* Annual Report, Department of Mines, 1887, p. 99.

† Ibid, 1886, p. 138.

From the Gordon Mines, Yeoval, the Minister for Mines exhibited a considerable quantity of ore, consisting of auriferous yellow sulphide of copper and a little zinc blende in quartz. The Inspector of Mines, W. H. J. Slee, F.G.S., gives the following account of this deposit:—*

"The formation in which this mine is situated is granite, and the lode or deposit occurs in an irregular mass of quartz veins in a circular form, which contain gold, carbonates of copper, copper pyrites, blende, and molybdenite. These veins have been taken out and crushed to a depth of 120 feet from the surface. The whole of the workings represent a pit or quarry, 120 feet in depth by about 70 feet in diameter. Everything, whether rock or quartz, has been crushed. . . . For the present the mine is being worked for gold only (copper being too low in price), the monthly crushings averaging 150 tons, and the yield of gold from 3 to 7 dwt. per ton. There are also about 1,000 tons of concentrated copper ore lying near the crushing machinery. Mr. Veitch, the manager, informed me that assays of the ore gave 9 per cent. of copper, 12 dwt. of gold, and 2 oz. of silver per ton."

Mr. C. A. Chesney exhibited a bulk sample of ore from the Chesney Cobar Gold-mining Company's Mine. It consists of ferruginous quartz and sandy slate, the gold being principally in the latter; the gold in fine grains being intimately mixed with the component particles of the sandy slate, assays of which have given very high returns.

Mr. C. A. Chesney, B.E., Civil Engineer, states:—†

The above property "consists of three blocks of 5 acres each and one of 10 acres, making in all 25 acres held under gold-mining lease, 50 acres held as a water right, and 100 acres of freehold land, making a total of 175 acres. The reefs, which are traceable all through the land under gold-mining lease, have a width of 160 feet on the surface. Four shafts have been sunk, in all of which payable gold, it is said, has been found. The 600 tons of ore at grass are estimated to return, by ordinary crushing, 2 oz. of gold per ton; while, if the chlorination process be used—some of the gold being very fine—an equal quantity may be expected to be saved from the tailings. Several bulk crushings have been made from this property. Two tons from the surface sent to the Sydney Mint yielded 4 oz. $10\frac{1}{2}$ dwt. gold per ton, while the assay of tailings gave 1 oz. $18\frac{1}{2}$ dwt. per ton, making a total of 6 oz. 9 dwt. per ton; the gold being worth £4 2s. 1d. per oz., a very high standard indeed. In fact, all the silver contained in the stone was valued by the Mint authorities at only one penny per ton, thus proving the good quality of the gold. The bullion assay was $\frac{966}{1000}$, silver, $\frac{30}{1000}$. A further lot of 28 tons were forwarded to Victoria. Fourteen of these yielded, by ordinary battery treatment, 1 oz. 17 dwt. of gold per ton, no assays having been made of the tailings. The other 14 tons were submitted to the chlorination process, which

* Annual Report, Department of Mines, New South Wales, 1886, p. 107.
† Mineral Resources Cobar District, Chesney, 1888, p. 7.

produced 2 oz. 3 dwt. 15 gr. of gold per ton. A further lot of 1¼ tons taken from a trench on the property, on treatment gave 1 oz. 2 dwt. gold per ton; so that the 31½ tons fair sample, taken from the mine and submitted to treatment, gave an average return of about 2¼ oz. of gold per ton, which at (say) £4 2s. per ounce value, equals a gross return of over £9 per ton, a good enough result when here are by late calculations an estimated quantity of auriferous stone in sight of 100,000 tons . . . .

"The freehold land of the company is so situated that it forms one of the best catches for storm water in the Cobar district, while for a machinery or residence site it is unsurpassed. Tenders have been called for the erection of a large gold-saving plant; and, at present, there is machinery on the ground which is capable, when erected, of putting through about 120 tons of stone per week. A large reservoir, to contain about 40,000 cubic yards of water, is being constructed."

I understand from Mr. Geological-Surveyor Anderson—who has cursorily examined this locality—that the reef is on the same line of fracture as the Great Cobar Copper-mine (though in all probability a fault has occurred between the two places, having a considerable lateral displacement), a fact which receives confirmation from the occurrence of gold in the latter mine; an assay made by the Department of Mines of the refined copper produced at Cobar revealed the presence of gold at the rate of 2 oz. 12 dwt. 4 gr. per ton.

The Mount Billagoe Prospecting Syndicate exhibited a bulk sample of ferruginous quartz and slaty lode-stuff from their mine. The following is from the Warden's report:—

"At Mount Billagoe, 30 miles north-west of Cobar, a shaft has been sunk 100 feet, and a drive put in 40 feet. A reef has been cut from which some samples of gold-bearing quartz were taken. Some of the stone tested, it is said, gave over 5 oz. of gold, and 90 oz. of silver per ton." *

Mr. C. A. Chesney, B.E., in his "Mineral Resources of the Cobar District, New South Wales," states:—

"From 1½ tons of stone taken from the 90 feet level by the present syndicate, and treated at the Ballarat School of Mines, the average return per ton by ordinary treatment was:—

	oz.	dwt.	gr.
Gold	4	10	10
Assays of tailings	1	8	19
Total	5	19	5
	oz.	dwt.	gr.
Silver	34	8	2
Assay of tailings	41	13	21
Total	76	1	23"

* Annual Report, Department of Mines, New South Wales, 1887, p. 108.

The occurrence of gold in payable quantity in the Barrier Ranges is evidenced by the exhibit from the Princess Midas Gold-mine, Purnamoota; assays of which are reported to have yielded very satisfactory results; the auriferous vein stuff consists of ferruginous quartz and copper ore, in one specimen coarse gold is plainly visible. From another mine in this district (M'Grath's Red Jacket Mine) the Minister for Mines exhibited auriferous quartz veinstone stained with green carbonate of copper, which yielded on assay 3 dwt. of gold per ton.

From the frequent occurrence of quartz reefs throughout this district, in many instances forming conspicuous objects in the landscape, owing to the removal by denudation of the softer enclosing rocks; it is extremely probable that prospecting, which has hitherto been principally, if not entirely, confined to searching for silver lodes, will yet reveal the presence of many reefs which will prove payably auriferous, whilst under the extensive alluvial flats formed from the degradation of the higher levels traversed by these reefs, payable deposits of alluvial gold may yet be found.

Gold in serpentine (marmolite), and associated with asbestos, was discovered by the Gundagai and Melbourne Asbestos Company, at their mine on Jones' Creek, about four miles from Gundagai. A crushing of twenty tons yielded at the rate of 2 oz. of gold per ton. The Government Geologist, who recorded the discovery in his Progress Report* regards it as an important one in connection with the various modes of occurrence of gold, and expresses the opinion that it is not improbable that nuggets of gold occur in such rocks in the same manner as masses of native copper sometimes do. In this case, however, the gold was as fine as gold leaf, and occurred between the layers of the marmolite.

Mr. Geological-Surveyor Pittman, who also examined this deposit, in his report † states that "the gold occurs in a similar lode (to the asbestos) consisting of serpentine identical with the adjoining country, but filling the space between well-defined walls, which in this instance, are from six to twelve inches apart. The gold ran out at a depth of ninety feet, and was last seen in the hanging wall, but was not followed up." Specimens of this interesting occurrence of gold were shown in the Minister for Mines' collection, and in that of Professor Liversidge.

Mr. J. H. Blatchford exhibited auriferous quartz, with galena, zinc blende, copper, and iron pyrites from Snobb's Reef, Braidwood.

From the Homeward Bound Gold-mine, Yalwal, were shown some very rich specimens of ferruginous quartz, the gold being very freely visible. Of this mine Mr. Pittman reports ‡—"The Homeward Bound Gold-mining Company are at present working an open quarry at the surface. The gold is visible in small veins

* Annual Report, Department of Mines, 1879, p. 217.
† Annual Report, Department of Mines, 1881, p. 140.
‡ Annual Report, Department of Mines, 1883, p. 159.

of gossan, running through the stone irregularly, and probably derived from the decomposition of pyrites. The last crushing from this spot yielded 1 oz. per ton nearly. The mine is also pierced by a long tunnel, nearly 300 feet, which was put in from the side of the mountain to strike the bottom of their shaft. Several slides came in this tunnel, each slide carrying a large body of stone containing from 4 to 10 dwt. of gold per ton. Several crushings were also made of stone taken from the shaft, where these slides were encountered, and yielded from 9 dwt. to 1 oz. of gold per ton, the richest yield being from near the surface. Another patch of 100 tons was extracted by quarrying at the surface near the shaft, and yielded an average of 3 oz. 13 dwt. of gold per ton."

The following additional particulars have been furnished by Mr. R. T. Thorburn, Managing Director:—

"The mine named above is situated on the right bank of Dangera Creek, a tributary of Yalwal Creek, which joins the Shoalhaven River, about thirty miles—as the crow flies—west of the mouth of the Shoalhaven.

"Yalwal Gold-field contains an area of ninety-seven square miles. Gold was first discovered there in the alluvial in 1852, and it was proclaimed a gold-field in 1876.

"The first Homeward Bound ground lease of five acres was issued by the Crown in 1877, but the ground was but spasmodically worked until it came into the possession of the present lessees, Messrs. R. T. Thorburn, John Faulks, jun., Reuben Mison, and Ephraim Mison. The lessees at that time being men actively engaged in other spheres of emolument, only a limited number of men were employed in the mine. There was, from 1880 to 1886, but one "public" reducing plant at Yalwal, and this battery was generally employed on trial crushings for prospecting parties. Hence the Homeward lessees, having to pay a high tariff for crushing, and being but feeling their way in the Homeward Bound treasures, had but the very best stone crushed in the battery, until it became their own property in 1886. Since then the stone has been almost indiscriminately put through the battery, giving the result declared further on.

"The lease occupies part of the western side of a ridge of quartzose rock, running nearly north and south, of an altitude at its apex of 300 feet above tidal water, and 250 feet above the adjoining stream, Dangera Creek. The ridge starts from the south table-land, and stretches north 10° west for about two miles, being but two or three chains wide at its crown, at the Homeward Bound, and narrowing off to a sharply-defined ridge, northerly, till it terminates where Dangera Creek is joined by Sawpit Gully Creek, twenty chains or so further north.

"The width and depth of the lode which is being worked—quartzite, with numerous thread-like veins of pure quartz, carrying gold,—is not yet defined, though in the claim under notice it has been taken out from a depth of sixty feet, and a width of over sixty feet.

"The records kept since 1882, show that about five men have been kept at work in the mine, exclusive of those employed in connection with the battery. The mode of conveying the stone from the mine to the battery is by horse traction; but the proprietory contemplate a more effective and economical mode of carriage by rail and gravitation. The battery is one of ten stamps, but with the immense quantity of payable stone now in view, a much larger battery could be kept in full work, with about the same complement of hands continuously working in the mine. The average yield of the stone since the mine was opened exceeds one ounce of gold per ton. The total value of the gold and silver produced to February, 1889, is £26,251 4s. 7d."

Mr. J. E. Kelly, M.P., exhibited samples of the auriferous lode-stuff from the Delaney's Dyke Gold-mine, near Molong, in which gold could be seen. The Government Geologist states that the lode consists of brown iron ore on the footwall side, passing towards the hanging wall side into siliceous "clinker," or chalcedonic quartz and contorted shale. It contains also garnet rock, and is stained throughout with copper carbonates. It strikes north and south and dips east at 40°, and is twenty-six feet wide on the surface.

Since the Government Geologist made the above notes, Mr. Kelly informs me that prospecting has proved the auriferous portion of the lode to increase from seven feet in thickness at thirteen feet from surface to twelve feet at the 100-ft. level. It has been driven on from this level about 100 feet north and south. At both ends the lode shows gold freely. No bulk crushing has yet been done from this level owing to want of water, but assays of picked samples have yicled up to 80 oz. of gold per ton. Sixty tons, taken from surface to sixty feet, yielded 1 oz. of gold per ton. The gold is very light-coloured, and consists of an alloy of two parts gold and one part silver. It is worthy of note that gold has been found in the garnet rock.

The Mount Gray Gold-mining Syndicate exhibited auriferous lode-stuff from Mount Gray. The following particulars were furnished by the Secretary to the Syndicate:—

"The property is situated on Grove Creek, between Trunkey and Tuena, in the vicinity of the Abercrombie Caves, and about twenty-seven miles from Newbridge railway station, on the Western line. The country consists of crystalline limestone interstratified with slate, both of which are striking north and south, and standing nearly vertical. To the west of the property is a massive deposit of limestone, in which occur the Abercrombie Caves. A parallel belt runs through the syndicate's ground, and in it the lode occurs in a very irregular manner.

The lode-stuff consists of a hard ferruginous quartz, with veins of white quartz, and others of a porous nature, intersecting it.

Mr. H. S. Cox, F.G.S. (Messrs. Cox and Seaver), who examined the property, states that at one place the lode traced by outcrops, is as much as 230 feet wide, and he concludes his report by stating that the work for a time will be of the nature of a quarry, fully 200,000 tons of ore being in sight, which he expected to yield about an ounce of gold to the ton. Nine different samples chosen by Mr. Cox yielded from 18 dwt. 1 gr. to 6 oz. 10 dwt. 7 gr. per ton.

IV.—Silver.

The display of silver ores was very large and varied, and the localities represented reveal how wide-spread is their occurrence, from Monaro in the south to Rivertree and Fairfield in the north, and from Sunny Corner in the east to The Barrier Ranges in the west.

The value of the silver and silver lead produced in the Colony to the end of 1887 was £1,806,349. The following extract from the Government Geologist's Report on the Silver-bearing Lodes of the Barrier Ranges, August, 1884, will be of interest:—

"I have examined eighty-one lodes, and there are a few others, the Day Dawn, Ophir, Black Prince, &c., that I did not see; but those above described include all the principal ones, and from them it will be seen:—

"1. That the geological formations which contain the argentiferous lodes of the Barrier Range Silver-field are mica-schists, clay-slates, and sandstones, traversed by numerous quartz reefs, and intrusive masses and dykes of coarsely crystalline granite (pegmatite), and diorite. Nearly all the lodes occurr in the mica schists, and they have been found over a tract of country 70 miles long and 30 miles wide, which has been only partly prospected, so that many more lodes will probably be discovered. But the metalliferous formations are known to occupy a much larger area, and extend to Kooringbury on the north, and on the east as far as the Eight-mile Tank on the road to Silverton, about 38 miles from Wilcannia. . . . . .

"2. That the lodes, with the exception of those of the Broken Hill and Pinnacles, which are chiefly composed of ferruginous quartzite, all consist either of brown iron ore (gossan) containing argentiferous carbonate of lead and galena in bunches, and sometimes chloride and chlorobromide of silver, and carbonate of copper; or rarely of argentiferous carbonate of lead and galena alone; quartz is sometimes, though not always, present, and, in one instance, baryta occurs. It is evident that the oxides, carbonates,

and chlorides have resulted from the decomposition of the sulphides, and perhaps arsenides of iron, lead, silver, and copper, &c., which will be met with in their original condition below the water-level. Sulphides of lead (galena), and in two instances, iron pyrites are even found above the water-level.

"3. That the lodes, without exception, are very inconstant in thickness, both in longitudinal and vertical extent, and many of them thin out entirely within a few yards. A surface plan of the numerous lodes would resemble the shrinkage cracks upon the surface of a dried piece of cross-grained wood; in fact, as before mentioned, the lode fissures were shrinkage cracks formed by the contraction of the rock mass after the intrusion of the igneous rocks."

"Some of the lodes appear to have been formed along an original joint in the strata, which is indicated by a well-defined wall in the lodes; and these will, I believe, continue to great depths, though varying in thickness in places."

Samples from various mines in this field were shown in the collection of hand specimens exhibited by the Minister for Mines.

The Broken Hill Proprietary Company, in the show-cases at the base of their trophy, exhibited a number of specimens illustrating the nature of the argentiferous ores occurring in this truly wonderful mine, viz.: massive carbonate of lead with chloride of silver; kaolin, with chloride of silver; manganese oxide (stalactitic, and mammillated), with chloride of silver; the former in some instances showing beautiful crystals of calamine (carbonate of zinc) and chloride of silver; beautiful coral-like masses of the latter were also shown. Native copper, with a coating of malachite, as a product of oxidation, and handsome dendritic forms of native copper were also displayed. Galena (sulphide of lead) is shown from the lowest level. In addition to the carbonate and sulphide of lead, the sulphate (anglesite) and phosphate (pyromorphite) were shown.

The following is the produce of the Broken Hill Proprietary Silver-mine, to January 24th, 1889:—

Ore treated.				Bullion obtained.				Fine Silver.	Lead.				Average of fine Silver per ton.
Tons	cwt.	qr.	lb.	tons	cwt.	qr.	lb.	ounces.	tons	cwt.	qr.	lb.	ounces.
170,391	6	3	11	31,259	19	2	10	7,782,549	31,027	11	1	10	45·67

From the reports of the general manager, Mr. Patton, and the metallurgist, Mr. Schlapp, it will be seen that during the six months ending November 30th, 1888, 55,846 gross tons of ore were extracted from the mine, which yielded an

average of seventeen per cent. of lead, and 42·9 ounces of silver per ton, at a cost of 18s. 9·65d. per ton for mining and placing in the mine-dumps, and £1 15s. 6d. per ton for smelting.

The cost of the latter being made up as follows:—

		s.	d.
Labour	... ...	9	8
Superintendence—Assay Office, &c.	... ...	0	6
Cost of coke	... ...	18	4
Cost of firewood	... ...	1	0
Limestone ...	... ...	4	10
Repairs, &c.	... ...	1	2
		£1 15	6

Mr. Schlapp reported that the limited water supply available during July and August, necessitating constant reusing, proved very destructive to the jackets of the furnaces owing to the water becoming highly charged with mineral matter.

It is worthy of note that the expenditure for coke during the above period was £71,002 17s. 11d. exclusive of freight, which amounted to £27,367 9s. 1d. The Australian supply of coke is recorded as being not only limited, but inferior in quality to the imported article—a stigma upon our coal industry which can surely be removed by increased attention to the manufacture of coke for smelting purposes.

The cost of timber for mine purposes was £22,050 8s. 10d. for the six months referred to. Tenders have been accepted for a monthly supply of 500,000 ft. from outside the Colony.

A concentrating or ore-dressing plant, with a capacity of treating 250 to 300 tons daily, was close upon completion at the time of report.

The total number of men and boys employed was 1,666, of this number 1,057 were engaged in the mine.

* The Government Geologist, thus alludes to this mine:—

"With the Inspector of Mines, Mr. Slee, I visited the Broken Hill Mine, and was shown through the underground working by Mr. Patton, the newly appointed general manager, and Captain Piper, mining manager. I was surprised at the large amount of work that has been done in proving this splendid lode to a depth of 316 feet, the water-level being about 240 feet. It is a true fissure lode, varying from 10 to 160 feet wide, and consists chiefly of porous iron and manganese oxide in places, more or less siliceous, containing carbonate of lead and chloride of silver, with occasionally carbonates of copper and zinc. These ores have resulted

* Annual Report, Department of Mines, New South Wales, 1887, p. 143.

from the decomposition of sulphides and arsenides, which will be found in unaltered original condition below the water-level. As one looks at the sides and headings of the drives, the gossan lode-stuff, with its cavities and joints sparkling with crystals of cerussite and chloride of silver, presents a most interesting and fascinating sight. In one large natural cavity in the lode the sides were lined with black stalactites of iron ore, spangled over with white translucent crystals of carbonate of lead and carbonate of zinc, together with pale green crystals of chloride of silver, treasures for a mineralogical museum. Sometimes the gossan is intermixed with kaolin and garnets, and in places occur angular fragments, embedded in various positions, and of all sizes, of mica slate, granite, and quartz, which had fallen from the sides of the fissure. The walls of the lode are well defined, especially the hanging wall, which, in two places I measured, dips to the N.W. at 65°, but the dip varies in other places, and has changed to the E. below the 217-ft. level in M'Culloch's shaft. I noticed that one projection on the hanging wall had been rounded and striated by a faulting or downward sliding movement northerly at an angle of 47°. This is an important feature, showing that though the lode must necessarily vary in width, it will continue, as far as the displacement or sliding movement of the hanging wall has taken place, probably to a great depth. The lode continues northerly with much the same character, narrowing and widening in places through block 14, 15, 16, and Broken Hill Junction, beyond which it seems to continue in irregular smaller lodes of a more siliceous nature, containing argentiferous galena and carbonate of lead and copper, with a little chloride of silver. To the south also it passes into quartzite lodes, containing silver, lead, and copper ores sparingly distributed through the lode-stuff. Similar unpromising quartzite lodes crop out again about 3 miles further south in the Rise and Shine Company's ground, together with several ironstone lodes, one 8 feet thick and others 1 foot and 1 foot 6 inches thick respectively, containing carbonate of lead, which, I was informed, gave an assay up to 80 oz. of silver per ton. These gossan and lead lodes should be prospected to greater depths."

The Broken Hill Junction Mine exhibited crystallized carbonate of lead, with carbonate of zinc and chloride of silver; also several massive blocks of carbonate of lead with carbonate of copper.

The Barrier Range Mine Managers' Association exhibited a very interesting series of ores from the following mines on this lode:—Broken Hill Proprietary, Junction, Central, South, and North.

The Broken Hill Block 14 Company exhibited handsome specimens of crystallized carbonate of lead, and pyromorphite. From the lowest levels massive galena was shown, also carbonate and sulphide of lead intimately associated, showing the transition by alteration of the sulphides into carbonates.

Smelting has lately been commenced at this mine, first with one and lately with two smelters, the output being 826 tons 0 cwt. 3 qrs. 4 lbs. of bullion, containing 822 tons 13 cwts. 0 qrs. 19 lbs. of lead, and 110,490 ounces of silver. Splendid concentrating machinery has been erected, and tried with most satisfactory results.

The ores from the Proprietary and Junction mines corresponded with those already described, with the addition of native silver in siliceous iron and lead ores from the latter mine.

The ores from the Central were siliceous ironstone, carbonate of zinc, and chloride of silver.

From the "South" the ores were siliceous ironstone with kaolin and chloride of silver, carbonate, sulphate and sulphide of lead, with iron and manganese oxides, and carbonates of copper.

From the "North," carbonate, phosphate, and sulphide of lead, with native silver and copper.

The Mine Manager's Association exhibited copper ore with chloride of silver from the War Dance Silver-mining Company, near Purnamoota. Referring to this mine the Government Geologist states*:—"Three small lodes have been opened in the slate country. In one which dips S.S.E. 45°, with a well-defined hanging-wall, carbonates of copper, richly streaked with chloride of silver, occur with the gossan. About 150 feet from this is another parallel vein, 4 feet 6 inches thick of gossan, carbonate of copper, and chloride of silver. Three chains further S.E., in a shaft 20 feet deep, another gossan lode, showing chloride of silver has been opened. These lodes, though small, yield rich ore, and appear to be of a permanent character."

From the Victoria Silver-mining Company, galena. From the Great Britain and Great Britain East Silver-mining Companies, galena and siliceous ironstone with galena. Galena from the Original Victory Silver-mining Company. Copper ore from the Red Flag Mine. Siliceous galena and carbonate of copper from the Silver King Silver-mining Company's mine. From the Rockwell Amalgamated Silver-mining Company (Limited) specimens of ferruginous quartzite with galena and garnets, ironstone with blue carbonate of copper, and samples of the country rock. Ores from the Sydney Rockwell Silver-mining Company. From the Kaiser Silver-mining Company sulphide and carbonate of lead, and portions of the lode showing kaolin and galena. Ironstone and manganese, with carbonate of lead, from 100-ft. level, Rising Sun Silver-mining Company. From 130-ft. level, White Lead Silver-mining Company, carbonate of lead assaying 107 oz. 16 dwt. of silver and 50 per cent. of lead, and carbonate of lead showing chloride of silver, galena assaying

* Annual Report, Department of Mines, New South Wales, 1887, p. 143.

51 oz. 9 dwt. silver per ton and 40 per cent. of metallic lead. From the Red Hill Gold and Silver-mining Company, from 70-ft. level, galena with pyrites, assaying 150 oz. silver and 7 dwt. gold per ton; also blende and pyrites. Galena and country rock (mica-schist) from the Shamrock Silver-mining Company. From the Maiden Silver-mining Company, schist with garnets from 35-ft., assaying 15 to 150 oz. per ton, and schist with galena. From the Great Barrier Copper and Silver syndicate, blue and green carbonates of copper; average assay, 29 oz. 8 dwt. silver per ton, and copper 29 per cent. Carbonate of copper from Copper Blow Copper-mining Company. Specimens showing uniform dissemination of galena through the lode from the Kinchega Rockwell Silver-mining Company. From the Alberta Silver-mining Company, Thackaringa, were shown by the Association some massive blocks of coarse and fine-grained galena of an assay value of 60·42 oz. silver per ton and 74·25 per cent. lead.

A similar ore was shown from the Pioneer Silver and Lead Mine, Thackaringa, assaying 49 oz. silver per ton and 82·25 per cent. of lead. The seconds for concentration (from this mine) yield 15·5 oz. silver per ton and 30 per cent. lead.

A siliceous, garnetiferous galena ore was shown from the Parnell Silver-mining Company.

The above complete the interesting suite of ores exhibited by the Association.

The Barrier Range Silver-field was also represented by a massive exhibit of blocks of galena (both coarse and fine grained) from the Gipsy Girl Silver-mining Company, Thackaringa, having an assay value of 43 oz. of silver, and 64 per cent. of lead.

The Government Geologist states*:—

"At Thackaringa, within a radius of 4 miles, upwards of thirty silver-bearing lodes have been discovered; of these I examined twenty-two. As they are nearly all of the same nature, viz., lenticular lodes of gossan, with carbonate of lead and galena, I need only describe a few, showing their characteristic features.

"On the Gipsy Girl Company's property, the No. 1 lode, which has been opened to a depth of 20 feet, following the underlay from the surface, and also in a shaft 40-foot deep, varies from 6 inches to 3 feet thick, and consists of carbonate of lead and galena, accompanied by quartz and ironstone stained with carbonate of copper. It dips N. 20° W. at 30°, traversing mica-schist, and is in one place divided by a horse of granite. It appears on the surface for about 7 chains, then a small ferruginous quartz and galena vein comes in, dipping E. 10°, S. at 35." Mr. Norman Taylor, in a special report made for this company, states that the ores from this mine average generally about 70 per cent. lead, and 35 ounces of silver per ton; and expresses a high opinion of the future permanence and productiveness of the vein worked.

* Report on the silver-bearing lodes of the Barrier Ranges, 1884, p. 9.

The Mascotte Silver-lead Mining Company exhibited splendid samples of chloride of silver, locally known as slugs, specimens of which having been cut revealed a face of metallic silver from the rubbing.

Mr. Joseph Morgan exhibited a quantity of massive coarse-grained galena from the Christmas Mine, Purnamoota.

The New Year Silver-mining Company, Lakes Camp, Barrier Range, exhibited a quantity of plumbiferous lode-stuff, richly impregnated with native silver, and chloride of silver, assaying at the rate of 10,500 oz. of silver per ton. A quantity of similar lode-stuff, with less native silver, yielding 1,260 oz. per ton; and fine-grained galena, yielding 72 oz. of silver per ton, and 80 per cent. of metallic lead.

The Pinnacles Tribute Silver-mining Company exhibited siliceous garnetiferous galena from their mine. Of this mine the Government Geologist says*:—

"The Pinnacles are situated about 15 miles S.E. from Silverton. There are two main lodes, one of them, the Minnie Moore, has a general strike to the north-west for about 10 chains. In one shaft, 7 feet deep, the lode is seen to be from 3 feet 6 inches to 4 feet wide, dipping W. 30° S. at 70° in talcose mica-schist, and consisting of ferruginous crystalline quartzite, with galena interspersed here and there through it, and patches of yellow gossan. An average sample taken from the whole width of the lode gave on assay at the rate of 78 oz. 8 dwt. of silver per ton, and 32·40 per cent. of lead; and of the yellow gossan, 22 oz. 1 dwt. of silver per ton, and 3 per cent. of lead, with traces (under 2 dwt.) of gold. The hanging wall is ferruginous chlorite rock. The lode winds about, and in one place suddenly widens to 30 feet; in two places it divides for a few yards, and then unites again, in others it sends out branches, which thin out entirely. Within 4 chains of it, on the north-east side, two other smaller lodes crop out. About 5 chains to the south west is a mass of ironstone 12 feet wide in the middle, then thinning out within a length of 50 feet. This forms the end of the Charlotte Greenaway lode, which runs to the south-west for about 10 chains, with a widening course like the lode just mentioned, and varying in width from 2 to 36 feet. It also consists of ferruginous quartzite, containing patches of galena. From the south-east side there is a branch lode, 15 feet long and 4 feet wide, with galena; and 50 feet off on the north-west side, is a separate and nearly parallel lode about 6 chains long, and varying in thickness up to 20 feet, with galena irregularly distributed through it. A sample of the ore which I took from near the surface, and consisting chiefly of galena, yielded on assay at the rate of 53 oz. 1¼ dwt. of silver per ton, and 41·12 per cent of lead, with traces of gold. . . . . It will be seen that these lodes are of large size, and I consider that they will be permanent. . . . . The chief silver-bearing ore is the galena, which occurs in

* Report on the Silver-bearing Lodes of the Barrier Ranges, 1884, p. 8.

patches and grains here and there, and much of it can only be separated from the hard lode-stuff by crushing and concentration. With careful working I think that considerable quantities of payable ore could be raised."

The Terrible Dick Silver-mining Company exhibited massive fine-grained galena with carbonate of lead.

The Umberumberka Silver-mining Company, near Silverton, exhibited a quantity of rich lode-stuff, consisting of fine-grained laminated galena, carbonate of lead, and carbonate of iron. Many of the specimens show native silver very freely.

The Government Geologist reports*:—

"The deepest shaft in the district is on the Umberumberka Silver Mining Co.'s lode, about 2 miles west of Silverton. Its depth is 181 feet, and at this level a drive has been put in along the course of the lode for 120 feet from the main shaft in one direction, and for 60 feet in the other. The lode occurs in mica-schists, and dips S. 25° E. at an angle of 75°. It varies in width from 4 to 10 feet, and consists of crumpled mica-schist, traversed by veins and lenticular bunches of brown iron ore or gossan, carbonate of lead, and galena. The hanging-wall is well defined, and coated with a black glossy clay; curved slickensides joints coated in a similar manner run through the lodes in places. The ore, which is said to yield from 70 oz. to 120 oz. of silver to the ton, is chiefly finely crystallized galena distributed in irregular masses in the lode. At the 181-ft. level one of the patches of ore was 12 feet long and 4 feet wide, and in this was a solid mass of galena 2 feet thick; near it iron pyrites is appearing, just as might be expected, for the manager, Mr. Evans, informed me that he had struck water in a bore put down only 2 feet below the floor of the drive."

"The Umberumberka is still the deepest mine in the field, the lode described in my former report having now been worked to a depth of 400 feet, or 267 feet below the water-level. From the 300–360-ft. levels the galena encloses small masses of antimonial silver ore. . . . . A short distance from the lode, on the north side, another lode has been exposed in the railway cutting, where it is 10 feet thick, and dipping S.S.E., almost parallel with the former lode. It consists of iron ore, has a good hanging wall, and every appearance of being a valuable and permanent lode."†

From the Silver King Silver-mining Co., lode-stuff was shown carrying galena and native silver, and assaying 114 oz. of silver per ton.

From the Uno Mine was exhibited a large block of ore largely composed of chloride of silver.

* Report on the Silver-bearing Lodes of the Barrier Ranges, 1884, p. 1.
† Annual Report, Department of Mines, New South Wales, 1887, p. 143.

Included in the general collection of silver ores exhibited by the Minister for Mines were samples of ores from the following mines in the Mitchell district: Sunny Corner, Tonkin's lease, Nevada, Great Western, Queen, and Monte Christo Silver-mines.

From the Sunny Corner Silver-mine, Mitchell, was an interesting exhibit of seventy-eight bars of metallic silver, weighing 11,214·5 oz., and containing 10,997·01 oz. of fine silver, and 129·8 oz. of fine gold. This exhibit was shown in an upright glass case surmounting a stand with blocks of the ores from which the silver was won, chiefly gossan and sulphide ore.

The Government Geologist gives the following particulars regarding the occurrence of these lodes*:—

"The primary or oldest formation of the district consists of sedimentary altered sandstone and shales. These have been upheaved and intruded by igneous rocks composed of quartzitic elvan and quartz porphyry, which have burst through the sedimentary strata in various directions, but principally north and south, as masses 20 chains, or as narrow dykes only 4 feet thick, consequently the line of junction between the formations is most uneven and irregular. After the eruption of the igneous rocks, fractures or displacements in the rocks took place on at least two different occasions, resulting in the opening of irregular fissures from a few inches to 40 feet wide, in which were deposited the gold and silver-bearing sulphides of iron, copper, lead, zinc, and arsenic, and quartz, constituting the lode-stuff now worked.

"Evidence of these displacements or movements in the rocks may be well seen in the Sunny Corner Mine. A dyke of the elvanite has been split in two, and the fissure filled with clay, showing that the fracture took place after the intrusive rock had solidified; then again the sedimentary formation has in places been displaced from its contact with the igneous rock, appearing to have slipped or moved bodily over the igneous rock, causing, where the original line of junction was curving or uneven, the projecting surfaces of the one formation to abut upon a projecting portion of the other, the intervening concave surfaces forming the irregular cavities now filled with lode-stuff, and, of course, where the line of junction was even or straight, the upper formation has moved upon the other without producing any cavity; consequently, where this occurs, the so-called lodes pinch out, though a well-defined fissure joint continues containing a thin seam of clay fluccan.

"In the Great Western Mine the two different sites of fissures are very clearly seen. We here see that along the line of fracture the surface of the rock has been grooved or striated by the friction or movement of one rock upon the other, and the fissure filled with fragments of the crushed rock. In this fissure-deposit

* Annual Report, Department of Mines, 1886, p. 139.

argentiferous sulphides of lead, copper, iron, and zinc have been formed in patches The fissure then opened again and became filled with clay, which, in one place is 20 feet thick, and somewhat resembles a decomposed felspathic basalt rock. Then shrinkage cracks formed in the clay-lode, and were filled with carbonate of lead, probably derived from the decomposition of the galena in the breccia lode.

"On account of the irregular manner in which the intrusive rock has been intruded, it is, of course, impossible to indicate where the line of junction between the formations is uneven; and, therefore, the whereabouts of any cavities filled with lode-stuff can only be ascertained by actual prospecting along the line of fracture. But we have a general guide in that the sliding movement of the upper formation has taken place towards the north-west; for the ore deposits already discovered occur chiefly upon the north-western slopes of the intrusive formation. This is an important feature, for it affords us assurance that in a north-westerly direction, below the deposits already opened; other similar irregular lodes are likely to be found.

"From the nature of the formation of the lodes, it will be apparent that there is no probability of the occurrence of one main lode in the district; but only of such as those which are at present known, and which are so variable in extent and thickness, notwithstanding that they are true fissure lodes. . . . It will thus be seen that the primary formation of this district consists of Siluro-Devonian sandstones and shales, which have been upheaved and penetrated by elvanite and quartz porphyry; that, subsequently, movements of the rock took place, resulting in the production of the fissures in which the metalliferous ores were deposited, chiefly about the line of junction of the sedimentary and igneous rocks: that these movements having affected the rocks to a considerable extent, the fissures will continue to great depths, though, owing to their irregular form, the ore deposits in them will vary much in thickness; that as these lodes are explored in depth, similar large patchy deposits to those already discovered are likely to be found; that the gossan or oxidized portions of the lodes occurring within about 100 feet from the surface, must soon be exhausted; that the less easily worked unoxidized or sulphide ores will be the permanent class of ores to mine; and that, as these usually are less rich in silver that the gossan ores, weight of ore considered, special appliances for concentrating the sulphides must be employed, especially as the ores are not rich in silver, and will necessitate the most economic methods of treatment, not only for the extraction of the silver, but also of the lead and copper, which are sometimes present to a large extent in the ore. . . I consider that silver-mining on this field will be a permanent and important industry; but its development, which must necessarily be gradual, must to a large extent depend upon (1) the concentration of the sulphide ores, for they are generally of low grade; (2) more economical methods of smelting the sulphides, which will be the permanent class of ore to operate upon; judicious exploration of the lodes;

for, as the ore deposits are very irregular in thickness, having originated, as I have already described, in fissure cavities of varying extent, it will be necessary that the prospecting of the lode should be kept well in advance. The gossan or oxidized portions of the lodes, occurring within 100 feet from the surface, must soon be exhausted, but the depth to which the undecomposed sulphide ores may be found is practically unlimited."

Included in the general collection mentioned above were specimens from the Boorook Silver-field; this locality, as in the case of Sunny Corner, was formerly worked for gold, though the presence of silver was known it was not until about 1878 that attempts were made to win the silver; chloride, bromide, iodide, and sulphide of silver occur in the lodes, the gangue being quartz, and soft red and blue claystone with pyrites, blende, and galena. A specimen of the quartz and pyrites of an assay value of 275 oz. of silver and 2½ oz. of gold per ton, was shown from Addison's lode; the claystone from the Golden Age, assaying 181½ oz. of silver, and 1½ oz. of gold per ton. The late Mr. Lamont Young, Geological Surveyor, who visited this locality shortly after mining operations were commenced, stated*:—

"The lodes are situated in belts of felspar-porphyry, alternated with beds of altered and fossiliferous shales, the fossils . . . . are indicative of the Upper Devonian formation . . . . The general strike of the reefs is a little to the east of north and west of south, with a slight dip to the west. . . . The silver-bearing minerals appear to be much disseminated through the matrix of the reefs. Argentite (sulphuret of silver) seems to be the chief source of the silver; there are also present chloride of silver and red silver ore. The associated minerals are iron pyrites in considerable quantity, free gold, copper pyrites, oxide of iron, galena, quartz, and chlorite; the latter mineral in some cases, as in the Golden Crown, forms the walls of the reef."

Mr. B. Davey, M.E., has the following remarks on the lodes which are represented in the collection, viz., Golden Crown, Addison's, and Silver King†:—

"The Golden Age Mine (lease No. 31) is a block of 2 acres, and distant about 2 miles from the granite range. The enclosing rock partakes of the character of a light-coloured talcose clay-slate (killas), which is peculiar to this mine. The lode has a bearing 22° east of north, with a dip or underlie west, and averages about 12 inches wide to the depth of 80 feet, and is composed of quartz, chlorite, clay, and a quantity of oxide of iron. The most abundant ore from surface to 80 feet was chloride of silver, with a little iodide and argentiferous pyrites. All the lode to this depth has been stoped out, and the chloride ore is now exhausted. The yield of silver from this ground has been over 52,000 oz., and 250 oz. of gold . . . . The former shaft (No. 1, 130 feet deep), cuts the blue or sulphide ore

* Annual Report, Department of Mines, New South Wales, 1878, p. 35.
† Annual Report, Department of Mines, New South Wales, 1880, p. 45.

at 80 feet, and the lode in the last 50 feet of sinking will average from 18 to 20 inches wide, with a vein on each wall 2 inches thick of rich argentiferous pyrites, which will assay from 70 to 150 oz. of silver per ton. The centre of the lode is composed of a soft blue clay, rather poor in silver. Water was struck in this shaft at 125 feet. No. 2 shaft cuts the blue ore at 82 feet, and the last 60 feet of sinking has gone down on a magnificent lode which will average 30 inches wide and rich in silver. The silver occurs in argentiferous pyrites and blende, some of which assayed as high as 800 oz. of silver and 5 oz. of gold per ton . . . .

"Addison's is a large champion lode, with well-defined walls, and certainly is worthy of being explored. . . . . .

"The adjoining claim north (from Golden Age) is the Silver King, with a shaft down 70 feet on the lode, which has penetrated the blue ore, but not rich in silver; and the chloride ores in this mine are not nearly so rich as they were in the Golden Age. This is the most northern point at which the lode has been seen."

Worthy of note also, in the collection, were specimens from the Little Plant Mine, near Emmaville—a larger exhibit from this mine was shown by the Company which was formed to work it, and named the Webb's Silver-mining Company, after the discoverer, Mr. L. Webb—the following description of its nature and occurrence, by Mr. Geological-Surveyor David, will be of interest, it being, as far as I am aware, the first discovery of importance of argentiferous fahlers in the Colony*:—

"The rocks in which the vein occurs are bluish-grey altered mudstones and claystones, passing at points of extreme alteration into white felstone and argillite. These altered palæozoic rocks are cut by numerous cleavage planes running principally 10° to 40° north of east and south of west, while their lines of bedding strike about 20° west of north and east of south, dipping westerly. . . . .

"Rising in places five or six feet above the level of the surrounding country, the silver vein forms a conspicuous wall-like mass as it strikes through these altered rocks. It may here be described as a breccia vein, composed principally of slate rock cemented and hardened by strings and bunches of quartz. The latter seem to have risen up, or segregated, partly along the cleavage planes of the argillite, and partly parallel to the strike of the vein.

"Towards the centre of the vein the cleavage planes of the slate rock may be observed to be much twisted, and occasionally the rock presents the appearance of having been shattered and recemented. There is no sign of walls or of slickensides.

"This mass of quartz-veined slate rock forms the capping of the vein, and can be traced for at least a mile and a half along the surface. Within this distance the reef throws off several branches, some of which die out, while others rejoin the main vein. Its average strike is 3° east of north and west of south, and its dip

* Geology of the Vegetable Creek Tin-mining Field, 1887, p. 156.

is about 73° westerly. The width of the main vein and its branches varies from one to six yards, but the metalliferous portion, as far as can be seen on the surface, is nowhere more than 3 feet wide, and is confined chiefly to the centre of the vein. . . . . .

"The chief ores found in this vein up to the present, are galena, copper pyrites, mispickel, and a variety of grey copper containing silver and a trace of gold (silver fahlerz). The mispickel, which does not appear to be silver-bearing, occurs principally freely crystalized through the clay-slate rock between the veins of galena and fahlers. The latter are associated with quartz and fluorspar. Much of the galena is fine-grained, and has returned silver at the rate of 148 oz. per ton. . . . . . Since the time of my visit the vein has been sunk upon at thirteen different points, and grey copper ore, rich in silver, has been proved to extend downwards for at least 210 feet from the surface. . . . . .

The following analysis by the Government Analyist shows the composition of the argentiferous grey copper :—

	In 100 parts.
Metallic copper	31·500
Do antimony	18·130
Do zinc	6·140
Do iron	6·440
Do lead	·680
Do silver	*1·635
Sulphur	26·180
Insoluble in acids (silica)	7·200
Trace of arsenic, gold, undetermined	2·095
	100·000

* Equal to 534 oz. 2 dwt. of metallic silver per ton.

The fact of the strike of this vein differing from that of the surrounding strata, and of the principal lines of cleavage, accounts partly for the absence of walls and of defined courses of ore, the ores being so much intermixed with the country rock in strings and bunches as to necessitate a great deal of dressing and selecting of the stone for treatment."

The White Rock Silver-mining Company, Fairfield, Drake, exhibited a massive pile of ore from their mine; one large block, weighing about two tons, well represents the character of the lode-stuff, which consists of a quartz and felsite gangue with strings and veins of zinc blende, galena, copper and iron pyrites. In some specimens small bunches of filiform native silver are present. The breaking of the lode-stuff along the course of a vein frequently exposes small cavities in which splendid examples of crystallization of the vein-filling minerals are seen.

The following is an extract from a report on this property by Messrs. Cox and Seaver, mining and civil engineers :—

"The property in question consists of two 40-acre blocks, held as mineral leases from the Government. It is situated at a distance of about 3 miles from the mining township of Fairfield.

". . . . The main country rock of the district is a 'porphyrite,' known locally as 'diorite'; and in the White Rock claim a creek has cut through this anl exposed, for some distance, a large felsite dyke traversed in all directions by veins, which consist of quartz on the surface, but at a few feet down change to a mixed ore, galena, fahlore, blende, and a little copper pyrites all occurring, and it is in these veins that the silver is chiefly found, although the rock itself also carries small quantities apparently disseminated through it.

"Along the course of the creek the felsite, with ore-bearing veins, has been exposed continuously for a distance of 500 feet, and for 392 feet further outcrops of the same rock have been found below a broken porphyrite, which occurs on the spurs of the hills. Extending back from the creek in a north-west direction the same class of rock is found as far as the boundary line between the White Rock and Pillar's claim, a distance of 583 feet."

"The greatest width of the exposure lies 335 feet back from the south-eastern face along the side of the creek, where it has been proved for a length of 710 feet along this line. . . . . .

"Of the ore in sight approximately one-tenth is lode-stuff, or, in other words, there is 71 feet in the width of 710 feet, consisting of vein material, of which the average assay is 215 oz. 6 dwt. per ton on the veins."

The following particulars of bulk parcels of the ore treated have been supplied by the Secretary to the Company:—

PARTICULARS of Ore sent to various Smelting Works and at the Mine, from the commencement to the 28th May, 1888.

Quantity of Ore.				Less Moisture.			Net weight.				Silver.	Price.		Gross value.			Sampling and Smelting charges.			Freight and other Charges.			Net Amount Received for Ore.		
Tons	cwt.	qr.	lb.	Cwt.	qr.	lb.	Tons.	cwt.	qr.	lb.	Oz.	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
7	17	0	15	1	2	8	7	15	2	7	131	3	$4\frac{4}{15}$	171	2	4	25	5	7	40	8	0	216	8	8
6	5	2	0	1	1	0	6	4	1	0	136	3	$3\frac{1}{3}$	140	3	9	20	3	10						
8	18	1	14	5	1	11	8	13	0	3	120	3	$2\frac{5}{6}$	167	19	5	66	2	5	84	0	0	193	17	4
11	16	1	0	2	1	13	11	13	3	15	94	3	$2\frac{3}{7}$	176	0	4									
1	19	3	0	0	3	5	1	18	3	23	177	3	$6\frac{1}{4}$	31	10	6	5	16	11	7	18	3	18	0	4
36	17	0	1	11	1	9	36	5	2	20	658	....		686	16	4	117	8	9	141	1	3	428	6	4

Quantity of Ore.					How Disposed of.
Tons.	cwt.	qr.	lb.		
34	17	1	1	....	English and Australian Copper Company, Limited.
1	19	3	0	....	Australian Smelting and Refining Company, Limited, Dry Creek.
0	2	0	8	....	San Francisco Works.
59	0	0	2	....	Aix-la-Chapelle Works.
95	19	0	11		
4,250	0	0	0	....	At Mine.
4,345	19	0	11	......	Total quantity of Ore.

Particulars of Ore treated from 28th May to 29th October, 1888.

Weight.				How disposed of.	Net Value.		
Tons.	cwt.	qr.	lb.		£	s.	d.
34	6	2	25	English and Australian Copper Company, Limited................	462	12	0
1	18	3	23	Australian Smelting and Refining Company, Limited, Dry Creek..	21	0	0
57	10	0	1	German Works...	724	1	7
93	15	2	21		£1,207	13	7
24	14	1	25	San Francisco Works (Assay Returns only).			
45	0	2	26	Swansea Works, per "Afghan" (despatched October).			
163	10	3	16				

Mr. T. Horton, jun., of Fairfield, exhibited samples of silver ore from the recent discovery at Rivertree, at the head of the Clarence River, about thirty-five miles from Tenterfield, which were estimated to yield 200 oz. of silver per ton and 20 per cent. of lead.

The Webbs Consols Silver-mining Company, near Emmaville, exhibited two trophies of ore from their mine. The ore in the first consisted of a quartz and felspathic gangue with arsenical pyrites, galena, zinc blende, and copper pyrites. The second trophy represented the result of more recent development in the mine, and showed a marked improvement in the ore, a greater percentage of galena being noticeable, and less gangue. 4 tons 17 cwt. of this ore recently treated at Footscray, Victoria, yielded 2 tons 18 cwt. 3 qr. 4 lb. of lead, one ton of which on being desilverised yielded 126 oz. 3 dwt. of silver.

This property is situated on the western bank of the Severn River, parish of Gordon, county of Gough, and is distant from Emmaville about ten miles in a south-westerly direction. The nearest railway station is that of Deepwater, about seventeen miles from Emmaville. The property comprises two hundred and twenty acres.

The following particulars are extracted from a report by Mr. Thomas G. Davey, in the first half-yearly report of the company, just to hand:—"There are five distinct lodes in your property, which are, from all appearances, true fissure veins. They consist generally of porphyry (quartz) traversed by veins of quartz, arsenical iron, copper and iron pyrites, zinc blende, and galena. Their actual width has not yet been ascertained; the outcrops, however, are distinct in places, and, together with trenches which have been made in various parts across the lodes, show them to vary from 10 feet to 35 feet wide. The lodes are enclosed in a porphyritic granite formation, which appears to be general for some miles around, with the exception of an occasional intrusion of metamorphic slate and basalt. . . . . . Since work commenced on your property the total amount of sinking done is 230 feet, and that of driving 18 feet. In all cases the prospects have been satisfactory. It will be observed that No. 2 shaft, which is at the lowest level, has produced more galena, and generally richer ore, than any of the others. This fact is very encouraging, as it goes to prove that, as greater depths

are attained, more defined, compact, and valuable deposits of silver ore will be discovered. Nos. 1 and 3 shafts as yet show no galena, but I am of opinion that when these shafts have reached the level of No. 2, it will be found that the arsenical iron will have given place to argentiferous galena. This opinion is partly confirmed, inasmuch that a shaft sunk on an adjoining property on the north . . . . . to a depth of 30 feet, on No. 1 lode, and at a lower level (about 50 feet), galena is being met with throughout the lode similar to that found at the surface of No. 2 and to that which we are now finding in No. 4 shaft on No. 4 lode."

Assays of the galena gave 95 oz. of silver per ton and 80 per cent. of lead. A bulk sample gave 75 oz. of silver per ton and 22 per cent. of lead.

Mr. Edward Irby exhibited silver ore consisting of galena in claystone, from Pye's Creek, near Bolivia, which was stated to yield at the rate of 100 oz. of silver per ton and 50 per cent. of lead.

The Mascotte Gold and Silver-mining Company, Drake, exhibited quartz and felspathic veinstone, with zinc blende and pyrites, from the lode worked by them, which is reported to be twelve feet in width, and to yield 1 oz. of gold and 100 oz. of silver per ton.

The Gordon Silver-mining Company, near Emmaville, exhibited massive blocks of felspathic lode-stuff with galena, zinc blende, and pyrites.

The Back Creek Gold and Silver-mining Company exhibited a large block of ore from the 40-foot level, No. 2 shaft, where the reef is five feet thick. The lode-stuff consists of quartz and talcose schist. The following description by the Inspector of Mines will be of interest*:—

"In June last the Back Creek silver deposits were inspected by me. These deposits are situated about 6 miles from Rockley, midway between George's Plains and the Newbridge Railway-station on the Western line. At the time of my inspection the works consisted of an open cutting, in which the gold and silver was first discovered, and a drive 60 feet in length to connect the open cutting with No. 1 and No. 2 shafts, the latter of which was 40 feet in depth.

"The silver deposits occur in irregular bunches and lenticular quartz-veins varying in thickness from 4 to 18 inches. Some of these veins contain a high percentage of silver and gold. Although the quartz-veins are thin, the fissure in which they occur is fully 5 feet in thickness, and the matrix between the quartz-veins is said to contain a small percentage of silver. Strike of veins, N. 25° W., with a westerly underlay towards a limestone formation. The general geological formation of the district consists of Silurian sandstone, shales, limestones, and talcose, chloritic, and micaceous schist. . . . .

* Annual Report, Department of Mines, New South Wales, 1887, p. 111.

"Back Creek is an old gold diggings, on which for years past, both alluvial and quartz were worked with payable results. Owing to the large percentage of silver, the gold realized a low price, which caused the abandonment of the quartz-veins in that district, but on the discovery of the Sunny Corner Silver mines, the Back Creek quartz-veins were retaken for the purpose of testing for payable silver deposits.

"36 tons 18 cwt. 1 qr. of ore was forwarded for treatment to the International Smelting Works, which yielded 3,406 oz. of silver, and gold at the rate of 15 dwts. per ton, which proves that by careful dressing of the ore and economically working the mine, highly payable returns may be anticipated. So far no galena or carbonate of lead have been discovered; but, as the mine has not been extensively opened, it may still be found to contain galena, also carbonate of lead. At present it is impossible to estimate the full extent of the value of the deposits."

The Tuena Silver-field was represented by exhibits from the Mount Costigan, Cordillera Hill, and One Tree Cordillera Silver Mines.

The Mount Costigan Silver-mining Company exhibited soft earthy gossan with carbonate of lead; some large and handsome crystallized specimens of the latter were also shown. The Company also exhibited about half-a-ton of silver-lead bullion, obtained from their ores. The following particulars have been kindly supplied by the secretary, Mr. A. A. Gallagher:—

"The mine is situated at Tuena, county of Georgina, and consists of 125 acres. Smelting was commenced on the 20th July, 1887, and has been continued at intervals since, in the two furnaces erected. The quantity of ore treated was 4,565 tons, yielding 106,084 oz. of fine silver, 659 oz. of fine gold, and 359 tons of lead, of a total value of £26,361. The Company employs upwards of 120 men, and has expended over £40,000 since the formation of the Company. Very extensive additions to the machinery are at present being made, which will greatly increase the output. A new shaft has been sunk to a depth of 100 feet, making in all three shafts. A wire tramway is being constructed to connect the mine with the smelters. The Company has paid £3,750 in dividends."

The Cordillera Hill Silver-mining Company had, as an exhibit, a handsome trophy of their ores surmounted by bars of the silver-lead bullion obtained from them. The ores consisted of carbonate of lead and copper, and sulphides of lead, copper, and iron, in a quartz and ironstone gangue; iron ore and limestone, for fluxing, were also shown in the trophy. In a case alongside were specimens of friable crystalline carbonate of lead, and a quantity of scheelite (tungstate of lime), slightly stained with green carbonate of copper. Several large blocks of ore from this mine were also shown on a table-stand close by.

The One Tree Cordillera Silver-mining Company exhibited a quantity of ferruginous siliceous gossan and schist.

Mr. Warden Smith, P.M., reports* that:—

"The district of Tuena has been brought prominently before the public during the year by the rich discoveries of silver ore at Costigan, near Tuena. A company has been formed and smelters erected. Four shafts have been sunk, and 30,000 oz. of silver obtained, valued at about £4,875; also 103 tons of lead.

"Another property was also put into a company, and called the 'Cordillera.' Smelters are being erected; shafts sunk upon the lode. A tunnel driven into the hill has cut the lode, which assays well."

The New Lewis Ponds Gold and Silver Mining Company exhibited a handsome trophy of their ore, reaching a height of about fifteen feet, on which the ores were arranged in the order of their occurrence from the surface to the lowest level attained, 150 feet, at which level the ores pass from ferruginous gossan with carbonate of lead into sulphides of iron and lead. The base of the trophy at about three feet high was surrounded by four glass-cases in which picked samples were shown, consisting of beautiful examples of crystallized native silver, as yet bright and untarnished; chloride of silver, in some instances filiform, and passing at one extremity of the filaments into native silver or *vice versa*; in the cases also were good specimens of carbonate and sulphate of lead crystals, which are very plentiful above the water-level. I append the following description by Inspector of Mines†:—

"The Lewis Ponds Mines are situated on the eastern slope of one of the high hills of the Lewis Pond, about 15 miles by road east of Orange, 4 miles south-east of the Old Icely Copper-mine, and 10 miles north of Ophir. The geological formation consists of altered sandstone, micaceous talcose slates, porphyry, and limestone. As far as the lode has been opened, it consists of gossan ore, containing chlorides of silver and carbonates of lead, with a fair percentage of gold. Very little, if any, galena has so far been met with. The lode occurs in bunches from narrow veins to 16 feet in thickness, and its strike is north-west 10° north, with a westerly underlay. About seventy assays have been made, and I was informed with an average yield of 60 oz. of silver, and 1 oz. of gold per ton. . . . . At the time of my inspection three shafts had been sunk, viz., the working shaft 87 feet in depth, with a winze in the north level 29 feet 6 inches, making a total on the lode of 116 feet in depth, and the length opened on the course of the lode was 110 feet. An air-shaft and a main shaft were also being sunk; the latter was 8 feet by 4 feet in the clear, was 50 feet in depth, and intended to strike the underlay of the lode at a greater depth. The ore out of the Lewis Ponds Mine could be raised at a comparatively low cost, owing to the gossan ore and the walls of the lode being soft and require very little blasting. Fully 500 tons of ore were at grass, and several hundred tons of ore were exposed to view in the mine.

* Annual Report, Department of Mines, New South Wales, 1887, p. 49.
† Annual Report, Department of Mines, New South Wales, 1887, p. 111.

"About 200 yards westerly of this lode, also in the Company's ground, is a large outcrop of limestone, and about 100 yards westerly of this is another outcrop containing minerals, on which an old shaft has been sunk many years ago, and in which a lode can be seen from 6 to 8 inches in thickness likely to contain both gold and silver."

The Mount Stewart Silver-mining Company, Denison Town, exhibited a quantity of ore from their workings, consisting of gossany ironstone, with carbonate of lead and galena; also in a small glass-case divided into compartments a complete suite of the minerals occurring in the lode.

The Government Geologist, who inspected this locality shortly after its discovery, states in his report that seven gossan lodes have been found, but only on two of them had prospecting been done at the time of his visit. One lode is 45 feet wide, dipping N.N.W. at 45°, and outcropping on the surface for a length of 200 feet. The lode is well defined, and consists of gossan with patches of quartzite and manganese, containing pyrites and sulphide of zinc, in the gossan occur patches up to nine inches thick of carbonate of lead and galena. Six samples taken from different portions of the lode yielded from 10 dwt. 21 gr. to 19 oz. 1 dwt. 2 gr. of silver per ton, and a trace of gold in some. The silver appears to be principally confined to the lead ores, which assayed 76·5 per cent. of metallic lead. Several other lodes from sixteen feet to fifty feet wide, and from 200 to 450 feet long, crop out in the vicinity of the lode described. The Government Geologist was of opinion, though the assays were low, the favourable appearance of the ore at the surface warranted the proper testing of each of the above-mentioned gossan lodes.

Mr. J. G. Griffin exhibited silver, gold, and copper bearing lode-stuff from the Eyrie South Mines, Wiseman's Creek, near Brewongle. The ore consists of rich blue and green carbonate of copper, ferruginous carbonate of lead, and sulphides of copper and lead. The Government Geologist, who examined this lode when it was formerly worked for copper, states:—

"The lode is in talcose schist, which dips S. 79° 45′, W. at 63°; it occupies the fissure of a fault, and strikes N. 15° W., and has a varying dip generally to the east. The ore occurs in bunches along the course of the fault and in off-shoots from it. The bunches and shoots of ore, together with some veins of quartz, are of irregular thickness, being from 1 to 18 feet. The ore is of a very mixed character. . . . It consists of the green and blue carbonates, sulphides, and black oxide of copper, with the sulphides of lead (galena), zinc (blende), and iron and arsenical pyrites; occasionally a little native copper is met with. Occupying, as it does, the fissure of a fault, this lode will doubtless prove to be a permanent one in depth."

The Captain's Flat Silver-field was represented by bulk samples from the Commodore and Vanderbilt Silver Mines, and hand specimens from the Koh-i-noor, the latter exhibited by Mr. C. L. Garland, M.P.

The Commodore ore consisted of yellow ochreous gossan, with carbonate of lead, and the Vanderbilt of porous ferruginous gossan. In the latter ore occur nests of chloride of silver, and assays have yielded very high returns of silver per ton. The samples exhibited by Mr. Garland from the Koh-i-noor Mine consisted of ferruginous carbonate of lead, and copper, and gossan. In connection with the latter mine Mr. Warden Woore, P.M., reports* :—

"I am informed that the total quantity of ore raised during the year is 2,346 tons, 2,106 tons of which have been smelted on the ground, yielding nearly 122 tons of bullion, containing, by assay estimates, 40,877 oz. of silver, 364 oz. of gold, 4¾ tons of copper, and 116 tons of lead; also 54 tons of copper matte, containing, by assay estimates, 4,828 oz. of silver, 18 oz. of gold, 15¼ tons of copper, and 8½ tons of lead; and there are from 60 to 100 tons of copper matte, the actual weight and value of which have not yet been ascertained. The remaining 240 tons of ore are now awaiting treatment."

Since the above report, I am informed by Mr. C. L. Garland, over 2,000 feet of sinking and tunnelling have been done in this mine, which has disclosed the presence of several thousand tons of very payable gossan ore, 500 tons of which have been sent to smelters.

Mr. Woore also states† :—"At the Vanderbilt Mine. . . . a shaft has been sunk 62 feet, from which a drive has been made W. 25 feet, intersecting a gold, silver, and lead bearing lode, about 8 feet wide, running north and south. About 150 tons of ore have been raised, from which a number of assays have been made locally, yielding, I am informed, from 10 to 180 oz. of silver, and from 1 to 4 dwt. of gold per ton."

In the Commodore Silver-mine, Captain's Flat, according to Mr. Garland:—4,000 feet of tunnelling and winzes have been carried out, all work, except shaft, in ore. Some very rich gold-bearing ore assaying as high as 3 oz. in bulk, with a fair percentage of lead and silver, has been opened up in this mine.

Two hundred and fifty tons of the ore have been sent to the 30-ton smelter, which has been erected in connection with this and the Vanderbilt mine (now amalgamated).

Mr. W. Bridle exhibited silver ore from the Yarrangobilly Silver-mine, Tumut District, consisting of massive galena and carbonate of lead, with traces of carbonate of copper. In this exhibit were some interesting specimens of galena, showing rhombic cavities, from which calcite has been removed.

* Annual Report, Department of Mines, New South Wales, 1887, p. 81.
† Annual Report, Department of Mines, New South Wales, 1887, p. 82.

Two parallel lodes occur in this property, one of which has been traced on the surface for about 300 yards, having a width of about three feet. Assays of the lode-stuff yielded from 20 to 98½ oz. of silver per ton.

About eighty yards to the eastward the second lode has been traced for about one hundred yards on the surface; it is twelve feet wide at a depth of twenty feet. Assays of the ore have yielded up to 20 oz. of silver per ton, and from 45 to 80 per cent. of lead. In one instance gold at the rate of 1 oz. per ton is said to have been obtained. Limestone and iron ore for fluxing are abundant, whilst timber of the finest quality is obtainable in unlimited quantity. The adjacent river can be utilized as a very powerful and economical motive power.

Mr. H. W. Jackson exhibited silver ore, consisting of galena in quartz from the Big Badja Silver-mine, Cooma District.

V.—Tin.

The approximate area of the tin-fields in New South Wales is 5,440,000 acres. According to the official report of Harrie Wood, Esq., Under Secretary for Mines, the value of the total production of tin to the end of 1887, amounts to £7,927,876. The tin ore, therefore, ranks next in importance to gold and coal as a source of wealth to the Colony. The existence of tin ore in New South Wales was known for many years, but it was not until 1871 that any attempt was made to turn this mineral to account as a marketable commodity. The most extensive deposits of ore have been found in the northern portion of the Colony, and a large area of country in the Barrier Ranges, in the north-west portion of the Colony, has proved to be stanniferous. Tin ore has also been discovered in other districts. The value of the tin obtained in 1887 was £525,420.

The ore has hitherto been obtained in the beds of water-courses, and it is separated from the gravel by sluicing. In some localities extremely rich deposits of drift tin ore have been found in the beds of ancient streams, at a depth from 60 to 200 feet below the surface. Valuable lodes or reefs have been discovered, and in some places crushing machinery has been erected to extract the ore. The tin-bearing granites of New South Wales belong to the same geological era as those of Cornwall. Many years will elapse before the ground now being worked will be exhausted.

In the Vegetable Creek Tin-field alone only about three miles of the deep leads have been worked out since their discovery in 1873, and it has been estimated that there are forty-six miles in length of deep leads yet to be worked, as shown on the geological map (exhibited) of that tin-field, by Mr. T. W. Edgeworth David, B.A., F.G.S., Geological Surveyor.

In his "Geology of the Vegetable Creek Tin-mining Field," the same author classes the deposits of tin ore as: I, Stream Works, and II, Veins.

"The stream works are subdivided into (*a*) "Shallow Leads," and (*b*) "Deep Leads."

(*a*) The "shallow leads" of Recent and Pleistocene age, are situated chiefly at the source of Vegetable Creek, and consist of loose sand, gravel and rubble, as well as hard, compact sheets of "cement" (a natural concrete formed of fragments of quartz-porphyry, cemented with felspathic material, silica, and oxide of iron). The width of this shallow lead varies from 1 to 5 chains. The "wash" occurs next the bed rock, at a depth of from a few feet to 15 feet from the surface, and averages 1½ feet in thickness. The lead has been worked for 5 miles down the creek from its source, in which distance it has yielded up to date over 20,000 tons of stream tin ore. Most of the stream tin is well rounded by the constant attrition to which it has been subjected for ages by the mechanical action of the water of the creek, while some is still sharp and angular, preserving its original crystalline form. Sub-angular and round pebbles of quartz-porphyry, containing minute veins of tinstone, are frequently found associated with the stream tin, clearly proving that the stream tin was derived from the disintegration of minute veins of tinstone, which traverse the quartz-porphyry at the bottom of the Vegetable Creek valley in such numbers as to constitute a vast stock-work.

(*b*) The "deep leads" are stream works formed in the beds of pre-historic dead rivers, the stanniferous gravels of which have been sealed up under stony sheets of lava and volcanic tuff to a depth of from 100 to 300 feet. These volcanic rocks belong to at least two well-marked periods, and the deep leads are thus subdivided into newer and older, the newer leads frequently containing pebbles of the older lava, and resting on a floor of the same material.

"The geological age of the older deep lead is proved to be early Tertiary by the nature of the fossil plants associated with the stream tin, amongst which are several varieties of beech, oak, and pines allied to the kauri and Wellingtonia, all of which are now extinct in the district, intermixed with banksias, grevilleas, laurels, and eucalypti.

"Some idea may be formed of the richness of these ancient river gravels from the fact that on the Vegetable Creek Tin-mining Company's property 2,000 tons of stream tin were won in an area of 5½ acres.

II. The tin veins, which number in the aggregate over ninety, are classed as—

(*a*) True (fissure) veins.

(*b*) Pipe veins.

(*c*) Stockworks.

The veins belonging to the (*b*) and (*c*) type are small, and as yet have not been worked to a profit.

"The most important veins, such as "The Ottery," "The Dutchman," "Butler's," &c., belong to the (*a*) type. The ore invariably runs in shoots, most of which dip obliquely along the plane of the vein at an average angle of 26° from the horizon, chiefly to the north-east. The average strike of the veins is 39° east of north and west of south. The underlie is chiefly to the north-west, at an average angle of 23° from the vertical.

"The average width of six of the largest veins is 3 feet, and the greatest length to which any one particular vein has been proved tin-bearing is 1 mile, and the greatest depth to which they have been worked over 200 feet.

"The minerals in the veins associated with the tinstone are:—Quartz, chlorite, felspar, mica, mispickel, iron pyrites, fluor spar, tourmaline, wolfram, blende, galena, copper pyrites, bismuth, molybdenite, vesuvianite, stilbite, hematite, pyrrhotine, manganese, scheelite, and beryl.

"The prevailing country rock is granite, but a few of the veins are enclosed in a chloritic quartz-porphyry and in claystone.

"The average yield of black tin from the veinstone, after it has been roughly picked, preparatory to being crushed, is 3½ per cent.

"The total amount of black tin won from the lodes up to date is about 2,000 tons.

The Minister for Mines exhibited a general collection, numbering one hundred and eighteen specimens of lode and alluvial tin ore, from the principal mines in the Vegetable Creek Tin-field, New England, and from other localities.

The following particulars from Mr. Geological-Surveyor David's Report, concerning the lodes, from which specimens were exhibited, will no doubt be of interest* :—

"*The Ottery* veins occur in dyke masses of hornblendic granite and eurite, within 8 chains from the margin of the claystone. The main vein with the cross vein has been proved to be productive of tin for a distance of over ¼ mile, and for a vertical extent of 169 feet. The well-defined nature of the walls, the strong slickensides, and the quantity of clay fluccan lining the veins, proclaim this to be a true fissure

* Geol. of the Vegetable Creek Tin-mining Field, 1887, p. 143.

vein. It will be noticed that in all cases where the inclination of the vein from the vertical became suddenly lessened, it became pinched and unproductive, confirming the well-known experience of miners that those parts of a vein which most nearly approach the vertical are generally the richest. The strike of the veins follows approximately that of the junction line between the porphyrite and claystone. The dip, except in the case of the west vein, is north-westerly, following the underground line of junction between the crystalline rocks and the claystone, give these ore bodies the character of contact deposits. The ore in these veins occasionally runs in shoots, which dip to the north-east, following, perhaps, the dip of the sedimentary rocks in the immediate neighbourhood. The shooty character of the ore is, however, less observable here than elsewhere. At the time of my visit, 1,200 tons of veinstone from these veins, crushed at Tent Hill, yielded a trifle under 5 per cent. of tinstone, and subsequent crushings have yielded a little over 3 per cent. As soon as the shafts and levels have been sufficiently extended to admit of stoping on a large scale, these mines should pay.

"*Butler's* vein has been traced for a distance of 1 mile through portions 173, 174, and 307, parish of Highland Home. . . . . The average strike of the vein is 35° north of east and south of west. The dip is north-west, varying from 72 to 85. The thickness varies from 2½ feet to 10 feet, averaging 3 feet 2 inches. The vein was being systematically opened up from its south-west end for a distance of 10 chains by Butler's Tin-mining Company. . . . . . The casing is eurite, passing into coarsely crystalline porphyritic granite. . . . . The tinstone occurs in seams and bunches, freely crystallized in chloritic quartz.

"*Elliott's* vein in Speare's portion 2A, parish of Annandale, and 149, parish of Highland Home, a continuation of the preceding vein (the Geyser), strikes 35° degrees north of east and south of west, is nearly vertical, and averages 9 inches in width. 6 tons of ore have been won from the vein, which averages 1½ cwt. of tinstone per cubic yard of vein stuff.

"*Old Gulf Lode.*—The Gulf Stream Company's lodes are situated in portion 23, parish of Muir, county Gough, and in portions 59 and 60, parish of Land's End. . . . . . The main body of ore was worked in portion 63, parish of Land's End, county Gough. The veinstone, in places 8 feet thick, averages 2 feet in width, consisting of chlorites, quartz, and decomposed white felspar; strike 1° south of east and north of west; dip, 72° northerly.

Some remarkably rich shoots of ore have been worked on this property, and are described as follows by Mr. David:—" A shaft sunk at the point shown on fig. 6 (on plan) struck a shoot of ore at a depth of 40 feet from the surface. The shoot, which was from 4 to 5 feet in vertical measurement and about 10 inches wide, dipped aslant the plane of the vein in an easterly direction, 20 feet vertically in a horizontal distance of 49 feet, producing 7 tons of ore. . . . . Another shoot commenced

at 8 feet from the surface, and was found to dip east gradually for a distance of 10 yards, where it pitched down at a steep angle. At 12 yards from the point of commencement, and 40 feet below the surface, the shoot was split by a horse of granite, part of the vein branching off in a direction west 35° north. Going east from this point, a very rich course or shoot was struck, perhaps a continuation of the preceding. The top of this shoot was 15 feet below the surface. The shoot itself was 15 feet deep, 127 feet long, and from half a foot to 8 feet wide, producing in that space 229 tons of tinstone, at the rate of 16¾ cwt. per cubic yard." At the 120 and 172-foot levels in this shaft two other shoots were met with.

"*Red Cross Lode* in portion 18, parish of Muir, county Gough, strikes 43° north of east and south of west, dipping 85° north-westerly; average width, 12 inches. The vein consists of nearly solid tinstone, replaced occasionally by quartz and chlorite. The tinstone is black, deep red, resin, and translucent. The ore at the centre of the vein is coarsely crystalline, but becomes finer towards the walls. The footwall shows faint slickensides. The vein is cased by hard quartzose granite. At the bottom of a shaft on the vein, 35 feet deep, the vein was 1 foot in width.

"*Curnow's Vein*, in the parish of Highland Home, county Gough, strikes 40° north of east and south of west, dipping 85° north-westerly. The vein is from 2 to 6 feet wide, averaging 3 feet, and has been traced along the surface for 18 chains. The veinstone is quartz and chlorite, well intermixed. . . . At 130 feet from, the surface the vein was tunnelled 35 feet west and 40 feet east, and was 6 feet wide at the shaft and 3 feet at the ends of the drives, and still tin-bearing.

"*Dutchman Lodes*, the vein known as "No. 1 Dutchman," strikes through portions 165, 166, and 167, parish of Highland Home, in a direction 34° 30′ north of east and south of west for 10 chains, then 38° 30′ for 12 chains, the vein having been traced on the surface for a total distance of 22 chains. The dip is 81° north-westerly, but the vein is vertical in places. The width varies from 3 to 6 feet averaging 4 feet. The foot and hanging walls are well defined, and show slickensides, and the granite casing is soft. The vein stone is principally quartz, with some chlorite. . . . . Several cavities were met with in the vein, 1 foot in diameter, lined with beautifully-formed crystals of clear and smoky quartz, 8 inches long, enclosing crystals of tinstone. . . . .

"No. 2 Dutchman strikes through portions 4A, 3A, and 2A, in the same parish, in a direction 28° east of north and west of south. The vein is 3 feet wide, and tin-bearing for 1½ feet. . . . The average yield of the total amount of ore crushed at these mines at the time of my visit was 3¾% of tinstone.

"*The Walleroo Vein* has been traced for a distance of 1½ miles . . . . in the parish of Highland Home, county Gough. . . . . The vein is from 1 to 4 feet wide, averaging 1½ feet. The vein consists either of a central crack, the sides

of which are lined with vein-stuff, merging into granite, or of a veinstone enclosed between well-defined walls. At the north-east end of the workings the vein has good foot and hanging walls, showing slickensides, the veinstone being separated from the hanging wall by a selvage of clay fluccan, 1 inch thick. . . . . The vein-stuff is composed of quartz, chlorite, and mica. . . . The ore is fairly well mixed through the stone, but occurs principally in small veins of quartz half an inch thick, traversing the mass of the veinstone. Seventeen tons of stone from this vein, crushed at Tent Hill, in 1884, yielded 2¾ cwt. of ore per ton. The strong strike of this vein, its great horizontal extent, and the richness of the vein-stuff invite further prospecting.

"*Yankee Veins.*—Three principal veins, so-called, worked in portion 99, parish of Land's End, may be distinguished as west, middle, and east. The west vein, averaging 1 foot in width, strikes 44° east of north and west of south, dip north-west, nearly vertical. Veinstone consists of quartz, chlorite, and tinstone, and is tin-bearing for a width of 2 inches.

"Middle vein, from 1 to 1½ feet wide, strikes north-east. Vein-stuff similar to preceding. Tinstone occurs in large beautifully-formed crystals in the quartz, and is distributed through the veins in the form of a shoot, pitching easterly. . . .

"*East Vein*, averaging 1½ feet in width, strikes 35° north of east and south of west, and has been traced on the surface 4 chains. In a shaft sunk on the reef . . . . at 15 feet from the surface, a large vugh was found 2 feet long, 2 feet deep, and 1½ feet wide, the sides being lined with magnificent crystals of tinstone and clear quartz. In some specimens the tinstone invests the quartz, while in others it is enclosed in it, showing that the silica and tin must have been in solution simultaneously.

"*Torrington Veins.*—Parish of Annandale, county Clive. The country is a coarsely crystalline granite, composed of triclinic and monoclinic felspar with abundant dark mica quartz, and a little muscovite and hornblende. Near the north-east end of the main vein the granite is fine grained and intersected by veins of eurite, which latter frequently forms one of the walls of the vein. . . The average strike of the vein is 36° north of east and south of west. The veins consist of fine-grained felstone or eurite, fairly soft from the surface to a depth of from 30 to 40 feet, when it becomes very hard. In some cases the veinstone is separated by a sharp line from the granite country, while in others it merges gradually into that rock. Tinstone occurs in disseminated crystals or thin strings in the felspathic vein-stuff, generally running in shoots or floors, the ore being partly black and partly resin; while some of the crystals are quite translucent. . . .

"The north-west branch of the main Torrington vein . . . . at 92 yards along its strike from its south-west end, the vein joins the main Torrington vein. A shoot of ore has been worked out of this branch vein, commencing near the surface at the point of junction, in a south-west direction for a horizontal distance of 120 feet, in which distance the shoot dipped 40 feet. . . . A rich shoot was worked here from near the surface to a depth of 135 feet. The shoot pitched 40° east of north and west of south, at an angle of 45°, and was 2 feet wide where widest, averaging 10 inches. The hanging wall was well defined. In part of the workings, an intrusive dyke of eurite formed the foot-wall of the vein. Close to where the cross course of eurite intersects the vein, a bunch of ore was got out of 64 cubic feet of vein-stuff, weighing 13 tons."

The Government Geologist states * that "*Graney's Lode*, in portion 54, parish of Land's End, is a very remarkable pipe-vein in hard granite. At the surface the vein or shoot consisted of an oval-shaped mass of ore with felspar 2 feet long and 18 inches wide; at 20 feet, it is said to have been 5 feet by 2 feet; and at 40 feet, the depth at which I saw it, it was 2 feet 6 inches long by 6 inches wide.

"*Pheasant Creek.*—The tin lodes at Pheasant Creek are similar in their occurrence to those at Ding Dong, consisting chiefly of detached blows of tin-bearing greisen in granite, and near the junction of the granite with metamorphic sedimentary formations."

In addition to the lode tin ores above described from the New England Tin-fields, and which were included in the collection exhibited by the Minister for Mines, the following private exhibits were shown:—

The Wheal Australia Tin-mining Company exhibited a quantity of rich lode tin ore from their mine, parish of Herbert, county Gough, between Cope's Creek and the Macintyre River. The tin lodes on this property, though rich and extensive, have not yet been developed. The company is preparing extensive works for the proper development of the deposits. The tinstone is very evenly disseminated through the veinstone.

The Torrington Tin-mining Company exhibited a large block of vein-stuff very rich in tinstone.

Jones and Party, from the 101-foot level in their mine at Vegetable Creek, exhibited a handsome block of tin-bearing lode-stuff, showing crystallized tinstone on the face.

Mr. Russell Barton exhibited a collection of tin-ores from New England, remarkable for the beauty of the tinstone crystals, many of which are seen investing quartz crystals, and in other specimens the tinstone crystals are seen to be enclosed in the quartz crystals, which as already pointed out, demonstrates the fact of their contemporaneous crystallization from a solution holding both minerals.

* Annual Report, Department of Mines, New South Wales, 1883, p. 150.

Mr. T. Mills exhibited specimens of rich lode tin ore, from No. 2 shaft, Westminster Lode, The Gulf, N.E., and a handsome specimen of associated tinstone and quartz crystals from a parallel lode to the Yankee lode before described.

Mr. S. L. Bensusan exhibited a block of rich tinstone from the Dolcoath Mine, Glen Creek.

Mr. Kennedy Hill exhibited lode tin ore from the Butler's Mine, already described. Whilst from about 8 miles from Tenterfield, Messrs. Kennedy & Bateman exhibited a very fine-grained siliceous tinstone, which assays at the rate of about 50 per cent of metallic tin.

Messrs. J. E. Kelly, M.P., and A. Delaney exhibited a quantity of ore from the Gumble Tin and Copper-mine near Molong. The Government Geologist who examined this mine, reports* :—

"The lode commences at the junction of granite and altered Silurian shales, and traverses the latter for about 100 yards in a north 80° east direction. It varies in width from 1 to 8 feet, and consists of ferruginous felspathic and siliceous lode-stuff, more or less impregnated with green and blue carbonates, grey sulphide, and red oxide of copper, brown oxide of tin, and magnetite. The tin ore principally occurs in the central and southerly portion of the lode. . . . . In a drive at the 100-foot level on the eastern side of the lode, for a distance of 15 feet, the country rock, altered rubbly shales, with serpentine in the joints, is found to be impregnated with native copper in bright crystalline, small grains and scales; and on the west side at the 60-foot level, the rock, for a distance of 14 feet from the lode, is, in places, stained with copper carbonates. It is thus evident that the rock on both sides of the lode has been more or less affected by the agencies, probably thermal water holding minerals in solution, which formed the lode. The lode contains tin, copper, silver, and traces of antimony and gold."

Mr. Kelly informs me that the result of a trial of a parcel of some tons weight at Parke & Lacy's Works at Pyrmont, was the concentration of the tinstone up to 60 per cent., and the copper up to 15 per cent.

The Barrier Ranges Tin-field was well represented by bulk exhibits from the Mount Euriowie, Euriowie West, Ruby, The Thistle, Trident, Victory, Wee Jim, Albion, Caloola, Cosmopolitan, Cosmopolitan Extended, Jubilee, and Lady Don Tin Mines.

The occurrence of the tin-bearing lodes in this district is described as follows by the Government Geologist.†

"The tin-bearing rocks have been proved over an extent of country about 28 miles long, in a N.N.W. direction, and 3 miles wide; but they are likely to be found over a much wider area, for the same formations are seen throughout the greater

* Annual Report, Department of Mines, New South Wales, 1886, p. 132.
† Annual Report, Department of Mines, New South Wales, p. 141.

part of the Barrier Ranges as far south as Thackaringa. These formations consist of metamorphosed clay slates and mica-schists, intersected by dykes of granite and quartz reefs. Tin ore (cassiterite) occurs in the granite dykes, not as veins, but in black crystals, in size from a mere speck or grain, hardly visible to the naked eye, up to 3 inches in diameter. It is not even disseminated through the granite, but is distributed more or less in patches, with a little ore scattered between them. In fact the cassiterite appears crystallized like the minerals composing the rock—the quartz, felspar, and mica—which occur separately or together, in coarsely crystalline patches in a fine-grained base of the same minerals. Sometimes one or more of these minerals predominate, so that in places the rock is chiefly composed of mica in large flakes, or of mica and quartz, or of mica and felspar, with crystals of tin ore and black tourmaline intermixed. The granite dykes themselves are very irregular in thickness and extent, either in length or in depth. In some instances, as at Lake's Camp, they suddenly widen out for 100 feet or more across, in others they divide into bunches, or form small oblong or boat-shaped masses.

"One of the most regular lodes yet opened is that which runs for about half-a-mile through the Euriowie north portions. In this also the tin is seen to be more regularly distributed through the granite than is usually the case. But even this lode, or granite dyke, which it really is, varies in width from 1 to 18 feet, and runs in breaks, thinning out at intervals, and making again within a few feet on the west side; nevertheless, the lode appears to be sufficiently persistent to be worked on a large scale.

"I was informed that a parcel of 20 tons of it, crushed at the Umberumberka machine, yielded at the rate of 8 per cent. of oxide of tin. The lode strikes N. 13° W., and has a westerly dip; it consists of coarsely crystalline granite with large flakes of mica, and traverses altered mica-schists, which strike north and south. The same lode continues into the Euriowie South Company's ground."

Caloola.—"On the Caloola Company's lode a shaft has been sunk, following the lode to a depth of 75 feet, and showing it to be much the same character as near the surface. Some 8 tons of 50 per cent. ore have been raised during the sinking of the shaft. The lode or granite dyke dips E. 35° N. at 75°; it is from 1 to 9 feet wide, and outcrops on the surface for about 200 yards; the tin ore is in patches through it."

Cosmopolitan.—"Similar tin-bearing granite lodes occur about three quarters of a mile to the N.N.E., in the Cosmopolitan and other mines.

Jubilee.—"One mile in a S.S.E. direction from here are the Jubilee Company's lodes. One, 18 inches wide but thinning out on the north end, consists chiefly of quartz and felspar, with but little mica; the tin ore occurs in patches, containing

about 10 per cent of tin ore. Another granite lode, 2 chains to the east is 2 feet 6 inches wide, and has been opened for 6 feet from the surface; only a little tin ore is visible in it."

Victory.—"On the same line of strike (as the Queen Victoria and Prince of Wales United Company's lode) towards the south, other lodes crop out through the Victory Company's ground. Some of these are being prospected, and a shaft 40 feet deep has been sunk in one 8 feet 4 inches wide. This lode strikes N. 10° W., and consists of coarse crystals of felspar, mica, and quartz, with tin ore in patches, which, if worked separately, would probably yield 20 per cent. of ore."

Trident.—"About 4 miles south is the Trident Tin-mine. Here, within a width of 130 feet, the slate formation is traversed by several granite dykes, one 12 feet wide, very micaceous and quartzose in places, with coarse tin crystals unevenly distributed. A shaft 60 feet deep has been sunk, and the shallow alluvial in a small gully draining from the lodes has been surfaced for a few yards, and several bags of "shed tin" obtained."

Albion Mine.—"On the south side of Yancowinna Creek, in portion 95, is the Albion lode of coarse crystalline granite in altered slate formation dipping W. 25°, N. at 80°; it would probably yield 12 to 15 per cent. of tin. A shaft has been sunk 22 feet deep, 100 feet further south a cutting 4 feet deep has been made showing the lode 7 feet wide, with a small patch of tin ore in centre. Near the south-west corner of portion 95 is a lode 25 feet wide showing a little tin and tourmaline; within 10 chains east are a few other lodes; one from 1 to 2 feet thick containing some tin and brown garnets has been opened 3 feet deep; it strikes N. 40° E. in chlorite slate."

Numerous samples of alluvial tin ore from various mines on the principal tin leads in the New England tin-field were included in the general collection of tin ores exhibited by the Minister for Mines. As these "leads" have contributed almost the whole of the tin produced to date, and are being successfully prospected at the present time, it is not deemed necessary to enter into details, as in the case of the tin lodes or reefs which have yet to be successfully worked. The known occurrence in the Colony of almost unlimited quantities of low grade ore should invite the attention of experts to solve the difficulty of low cost dressing and concentration, upon which depend the financial success of the practical development of most of our tin lodes, and especially those of the Barrier Ranges Tin-field.

Amongst the stream tin specimens shown were some tin-stone "nuggets" from Butchart's Mine. As these came from a very peculiar deposit, the following notes by the Government Geologist will no doubt prove of interest.*

"It was in a small gully which runs through portions 9 and 10, parish of Muir, that these remarkable nuggets of tin ore were obtained. One of the nuggets

* Annual Report, Department of Mines, New South Wales, 1883, p. 149.

weighed 32 lb. The alluvial in which they occurred was only about 6 feet deep and 2 chains wide, with porphyritic granite cropping out at the surface on both sides, but no lode was discovered, the granite is much jointed, the joints striking N.E. and S.W."

The Wheal Victoria Tin-mining Company exhibited a quantity of rich tin gravel from their mine, parish of Herbert, county Gough, between Cope's Creek and the Macintyre River. The alluvial deposits on this Company's property are very extensive, and vary from one to four feet in thickness over an area 1,000 yards wide, and yield fully 2 cwt. of clean tin oxide to the ton of wash. A substantial dam, washing plant, and horse machinery are now on the property; and sluicing is regularly carried on. The output equals ten tons per week when in full work. The exhibit comprised tin-bearing gravel and dressed tin oxide, together with the associated gem stones from the drift, sapphire, oriental emerald, topaz, and zircons; also some very large quartz crystals. The gem stones shown were small, and of no commercial value.

VI.—Copper.

Several copper lodes are being worked in the Colony; the principal ones are the Cobar, Nymagee, Burraga, Mount Hope, Thompson's Creek, and Balara.

According to the official report of Harrie Wood, Esq., Under Secretary for Mines, the value of the production of copper during 1887 was £199,102; together with copper regulus valued at £1,236; and the value of the total production to the end of 1887 amounted to £5,163,352.

The approximate area of cupriferous country in New South Wales is 6,713 square miles.

The Minister for Mines exhibited a collection of sixty-two hand specimens of copper ores from the various mines in the Colony; also bulk samples from the Great Cobar, Nymagee, New Mount Hope, Burraga, Gordon, and Gumble Copper Mines; and 4 tons of refined copper from the Cobar Mine.

The ores from Cobar consist of rich blue and green carbonates, red oxide, grey and yellow sulphides of copper. Of this mine, the late Mr. Lamont Young, Geological Surveyor, reported*:—

"The workings are on what is known as the West Lode. On the surface there appears the outcrops of two adjacent parallel lodes. . . . . . The great characteristic point in the Cobar Mine is the great variation in the width of the lode, namely, from a mere film to 100 feet. This may be explained by the fact that in slate rocks it would be natural for the sides in places to fall together, closing the fissure at some points, but, by this means, keeping it widely open at others."

* Annual Report, Department of Mines, New South Wales, 1880, p. 262.

The Inspector of Mines states*:—

"The greatest depth obtained by sinking the main shaft is 564 feet, from which level diamond-drill bores have been put down an additional 60 feet, the lode being 40 feet in width, of fair yellow sulphide ore. Stooping is carried out on the 15, 28, 39, and 54 fathoms, and some intermediate levels; but, with the exception of the 54-fathom level, the ores obtained are carbonates, oxides, and grey ores, which average about 16 per cent. of copper. A new discovery has been made between the 29 and 36-fathom level which would average about 14 per cent. But independently of this find it will take years to work out the different copper ores in sight, and known to exist in the mine."

An assay of the refined copper smelted from the above ores gave 99·65 per cent. of copper; 2 oz. 12 dwt. 4 gr. of gold, and 1 oz. 5 dwt. of silver per ton.

The following particulars of the quantity and value of the output from the Great Cobar Copper Mine have been supplied by the Secretary to the Company:—

From June, 1876, to 30th June, 1888—

	Tons.
Ore raised	197,650
Ore smelted	197,580
Refined copper obtained	22,354
Value realized	£1,827,332

Mr. Russell Barton exhibited, amongst others, some exceedingly handsome specimens of rich green and blue carbonates from this mine, together with specimens of the other ores, and native copper.

The ores shown from the Nymagee Copper-mine, forty-two miles south-east of Cobar, consist of earthy blue and green carbonates and grey and yellow sulphides. The metallic copper obtained from these ores is of the purest quality, being remarkably free from injurious foreign metals. An assay of it gave 99·74 per cent. of metallic copper, with 3 dwt. of silver per ton, and no gold.

Mr. Geological-Surveyor Young states†:—Two lodes occur in this property; the main lode striking N. 17° 30′ W., is nearly vertical, and has a width of about 8 feet. The second lode, known as the east lode, strikes N. 18° W. The ores consist of earthy blue and green carbonates, grey and yellow sulphides of copper.

The Inspector of Mines, in his Annual Report for 1884, states that the yellow sulphide ore has been traced through the mine for a distance of about 500 feet, averaging in parts from 10 to 15 feet in width. . . . . . In Pope's shaft, between the 50 and 70-foot levels, the lode consists of carbonates mixed with earthy matter about 40 feet in width; some of which is rich enough to go direct to the ore-breaker, and the remainder is treated through the crusher and jigger.

* Annual Report, Department of Mines, New South Wales, 1884, p. 121.
† Annual Report, Department of Mines, New South Wales, 1880, p. 261.

The following particulars of the quantity and value of the output from this mine have been supplied by the secretary to the Company:—

From January, 1881, to 30th June, 1888—

	Tons.
Ore raised	85,100
Ore smelted	84,159
Producing refined copper, realizing	£735,557

The ores shown from the New Mount Hope Copper-mine consisted of blue and green carbonates, grey and yellow sulphides. The Inspector of Mines thus describes* this mine, which is situated eighty miles south of Nymagee, forty miles north-west of Euabalong, and seventy miles north of Hillston:—

"The outcrop of copper in the New Mount Hope Mine occurs on the summit of a small hill, a characteristic feature of all the outcrops of copper lodes so far discovered in the north-western district of New South Wales. The geological formation is an altered sandstone (Devonian), with belts of irony sandstone. The lode has a strike of N. 7° 30' E., and has been opened along the surface for about 200 feet in length; it averages in parts 30 feet in width, and has been taken out in open cuttings to a depth of 50 feet. A few feet westerly of the open cuttings a main shaft had been sunk 150 feet in depth, and drives opened at the 100 and 150-foot levels. At the 100-foot level the lode had been driven across for 50 feet, and on the 3rd of March last, the day of my departure, had not reached the eastern wall; the lode, though in parts dreggy, with small horses (blocks of rock) consists of high percentage ores, such as grey sulphides, red and black oxides, green and blue carbonates and silicates, and a small percentage of yellow sulphide."

From Mr. Lewis Lloyd's Burraga Copper-mine was exhibited four tons of rich yellow sulphide ore. The Inspector of Mines has the following report on this mine†:—

"The mine is situated on a high range on the Abercrombie Mountains; and *via* Rockley it is about 50 miles south of Bathurst. The country surrounding Burraga has a highly cupriferous appearance, and presents indications favourable to the existence of other copper lodes than those at present at work. The Burraga copper lodes which occur in the Silurian formation, were discovered and first worked about 6 years ago. . . . . . The ore in the Burraga lodes, instead of being found in bunches, as has been generally the case in this district is found in shoots, with a north-east strike. Of these shoots there are several, but the largest so far opened and stopped on is 110 feet in length, the ore averaging from 4 to 9 feet in thickness. The lode contains very little carbonates and oxides, but mainly consist of yellow sulphides, partly intermixed with quartz. The lodes near the surface are very thin, but have so far increased in size and quality as a greater depth has been reached.

* Annual Report, Department of Mines, New South Wales, 1884, p. 126.
† Annual Report, Department of Mines, New South Wales, 1884, p. 126.

The Mining Registrar for the Burraga District, in his report for the year, states*:—

"Previous to the 1st September last, mining in this division was at a standstill, owing to the low price of copper. Since that date work has been resumed in the Burraga Mine, and at present there are fifty-three men employed, who have raised 1,154 tons of ore, yielding 120 tons of smelted copper; value, £7,200. The mine is worked to a depth of 240 feet, and shows a splendid face of ore; other lodes are also being opened on Mr. Lloyd's land."

The New South Wales Commissioners exhibited ten tons of metallic copper from this mine; it is of first quality and very free from base metals.

The copper ore from the Gordon Mines, Yeoval, which has hitherto been worked for the gold which it contains, has already been described under the head of gold.

The Gumble ore, having a greater value as a tin ore, will be described under that head.

Mr. W. B. Campbell, the proprietor of the Belara Copper-mine, which is situated about thirty miles from Wellington, had an interesting exhibit from that mine, illustrating the varieties of ore, the associated rocks and minerals, and the various stages in the metallurgy of copper, as pursued at Belara. One hundred ingots of metallic copper were included in the display. Firebricks were shown made from material obtained on the property. A schist, used as a lining in the furnace, was shown; this, on assaying, was found to contain several ounces of silver per ton. Indeed, silver in varying quantities must be present in the ores; the metallic copper contains at the rate of 50 oz. of silver per ton.

Mr. T. L. Richardson, of Murrawombie, exhibited a quantity of copper from the Girilambone Copper-mine. It consists of earthy blue and green carbonate of copper.

The late Mr. L. Young, Geological Surveyor, who examined this property before work was commenced, thus described the surface indications† :—

"The copper deposit is situated on No. 5, West Bogan Block, near the N.W. corner, and on the summit of a small hill, known as Copper Hill. The lode has a strike N. 18° W., and dips at an angle of 56°. At surface, the lode was 18 feet wide, and composed of veins of quartz, including between them bands of slate and occasional bunches of extremely rich red oxide of copper coated with green carbonate."

The Inspector of Mines, who visited the mine in 1884, says‡ :—

"Several bunches of ore have been met with in sinking. The first of these deposits was struck at 86 feet from surface, and for about 14 feet contained gossan and ore. At the 100-foot level, a band of ironstone was met with and sunk through

* Annual Report, Department of Mines, New South Wales, 1887, p. 55.
† Annual Report, Department of Mines, New South Wales, 1880, p. 262.
‡ Annual Report, Department of Mines, New South Wales, 1884, p. 120.

for 7 feet in thickness; and at the 122-foot level carbonate and black ores were met with. At the 300-foot level, in a drive 34 feet to the westward of the shaft, black ore and a small percentage of yellow sulphides were driven through; but the whole of these deposits appear tc be of a broken nature; at the time of my inspection yellow sulphide ores were discovered in sinking, which, although of good quality, and might be dressed up to 20 or 25 per cent., was, nevertheless, very dreggy, and not payable for hand-dressing, but require crushing and jigging. It, however, proves beyond doubt that numerous copper deposits are scattered through the hill, and that probably as greater depth is reached, and cross-cutting is pushed ahead some of these deposits may form into a solid body of a yellow sulphide lode."

The specimens of the richer ores described were included in the Minister for Mines' Collection.

Messrs. Rae and party exhibited grey and yellow sulphides of copper from Apsley, three miles south of Wellington.

Mr. D. Ferguson, M.P., exhibited a quantity of ore from a copper mine close to the town of Wellington. The ore consisted of grey sulphide with traces of carbonate, and was of low grade.

Interesting hand specimens of copper ores, from various localities in the Colony, were also included in the splendid collections of Professor Liversidge and Mr. Isaacsohn.

VII.—Antimony.

Antimony has been found in numerous parts of the Colony. The principal lodes occur in the Macleay, Armidale, Clarence, and Cudgegong Districts. The lodes near Armidale are payable auriferous. The value of the antimony exported to the end of 1887 was £67,239.

The Minister for Mines, in addition to the bulk exhibit of auriferous stibnite (sulphide of antimony) from the Eleanora Gold and Antimony-mine, Hillgrove, near Armidale, exhibited a collection of thirty-one hand specimens from the different localities in which antimony ores occur in the Colony.

The occurrence and character of the Eleanora lode has been described by the Government Geologist, and his description has been given under the head of gold, as the presence of the latter metal gives this deposit its chief value.

The Macleay River district antimony deposits were described by the late Mr. L. Young, Geological Surveyor, as follows*:—

"The antimony deposits are situated on the Munga Creek, 4 miles above its junction with the Macleay River, and occur in rocks which, judged from their lithological character, are of Devonian age. In the neighbourhood of the mines,

* Annual Repor Department of Mines, New South Wales, 1880, p. 250.

the strata have been highly disturbed, causing the country to assume a broken character, a point which, taken in connection with variation exhibited in the strike of the lodes, and the frequent appearance of "slickensides," may be considered as favourable to the presence of mineral deposits of an irregular nature.

"The antimony ore occurs in irregular bunches, occasionally of considerable size, enclosed in a quartz matrix, which forms the chief constituent of the lodes. The ores consist of stibnite (sulphide) and cervantite (oxide). The stibnite is of a high degree of purity, and the cleavage faces of crystals are remarkably large and brilliant."

Messrs. Lark & Sons, Moore-street, Sydney, exhibited a large trophy from their Carangula Antimony-mine, Macleay River District, consisting of antimony ore, star antimony, regulus, &c.

In the Departmental collection were samples of rich cervantite (oxide of antimony) from Ford's Creek, near Gulgong. Messrs. J. R. Bingle & Co., of Macquarie-place, Sydney, also exhibited from this locality a large block of similar ore, which assays upwards of 70 per cent. of metallic antimony. The Government Geologist who inspected this lode shortly after its discovery, states*:—

"At the head of Ford's Creek, 6 miles south of Gulgong, three small breccia lodes, or short 'blows,' containing sulphide and oxide of antimony and a little quartz, have been opened to a depth of 5 feet. They occur in irregular fissures formed where the strata (Silurian clay-slates and sandstones, S. 10° E. at 25 feet) have been fractured. The antimony ore occurs in irregular bunches, and as it is impossible to determine the extent of the rupture of the strata without sinking upon it, the probable value of the lodes can only be ascertained by actual prospecting."

In the Clarence River District, on the Yulgilbah Station, are fair lodes of antimony sulphide. Mr. Geological-Surveyor Pittman, who examined them in 1880, is of opinion that they will be well worth prospecting in the future, but until railways have been constructed the means of carriage are too imperfect to admit of their being worked at a profit.

The Cudgegong antimony deposits are thus described by the Inspector of Mines†:—

"The Rockwell antimony-mines are situated about 4 miles north-west of Rylestone, and 8 miles easterly of Cudgegong, near the Cudgegong River. These deposits occur in the slate formation, and are surrounded by metamorphic and micaceous rocks. The ore is associated with quartz, which forms irregular veins underlying west, some of these veins varying from 3 inches to 4 feet in thickness,

* Annual Report, Department of Mines, New South Wales, 1886, p. 136.
† Annual Report, Department of Mines, New South Wales, 1884, p. 124.

containing a high percentage of antimony. * * * * Very little work has been done on these lodes, but being so very near the Rylestone railway these antimony lodes are almost sure to be worked extensively, provided the price of antimony will rise in the market."

Hand specimens were also shown from Rocky River, New England; Caledonian Reef, Nundle, Lunatic, Peel River; and Razorback, near Ilford—the latter being auriferous, is described under the head of gold.

VIII.—Bismuth.

Bismuth ores have been found in the tin-bearing drifts, and also in lodes at Silent Grove, The Gulf (in the Vegetable Creek District), Kingsgate, and Hogue's Creek, near Glen Innes, Elsmore, Tenterfield, Adelong, Mount Gipps (in the Barrier Range, and Gumble in the Molong District; and quite recently near Captain's Flat in the Molonglo District, where it occurs in the form of tetradymite (telluride of bismuth).

The value of the bismuth produced to the end of 1887 was £20,575 14s.

The only bismuth deposits at present being worked are those which occur at Kingsgate, about sixteen miles east from Glen Innes. The Government Geologist who examined them in 1883 gives the following account of their occurrence*:—

"The formations here are granite and altered slate, forming rough broken country, with valleys about 500 feet deep. The line of junction of the two formations is well defined, and the bismuth lodes occur in the granite in proximity to this line, or within about 400 yards from it.

"The mode of occurrence of these so-called 'lodes' is very remarkable. They are pipe-veins or oval masses of quartz of variable thickness, descending in a more or less vertical direction in the granite, as though well-like caverns of very irregular diameter had been formed in the granite, and filled with quartz and metallic minerals. Thus in one lode in the Kingsgate Company's property two masses of quartz (which the manager, Mr. Yates, informed me were 30 feet apart on the surface), on being followed down, united and formed one large pipe-vein about 27 feet in diameter, and of irregular shape, from portions of it protruding here and there into the granite. Nests or bunches of bismuth ore (native bismuth, sulphide, carbonate and oxide of bismuth) were obtained about these protruding portions as well as through the mass of the quartz, and in order to take out the veinstone a large excavation about 60 feet by 40 feet has been made. The vein has only been sunk upon to a depth of 50 feet. The quartz is of a coarsely crystalline nature, and contains, in patches, a considerable quantity of molybdenite. The metallic bismuth and sulphide occur in the solid quartz, but the carbonate and

* Annual Report, Department of Mines, New South Wales, 1883, p. 154.

oxide lie chiefly in the joint fissures in the quartz. Sometimes masses of native bismuth are found between crystals of quartz in the vein, and when removed the impress of the quartz crystals is well shown. . . . . The largest mass of native bismuth found here weighed nearly 30 lb.

"Other similar veins, but smaller, have been proved, though only for a few feet in depth. . . . .

"On portion 25, about half a mile north-west from here, another large pipe vein is being opened; near the surface it consists of a very ferruginous mass of quartz, about 13 feet by 9 feet, containing bismuth, arsenical pyrites, wolfram, and molybdenite. The screened vein-stuff is said to yield about 50 lb. of bismuth per ton. . . . . A sample of the ore, consisting of mixed particles of native bismuth, carbonate, sulphide, and oxide, yielded on assay—

Metallic bismuth	69·3 per cent.
Fine gold, at the rate of	4 oz. 1½ dwt. per ton.
Fine silver, at the rate of	57 oz. 3 dwt. per ton.

. . . . . Several veins of a similar nature have been opened on the Glen Innes Company's property, which adjoins that of the Kingsgate Company. . . . About 3 miles from the Yarrow Head station, and about the same distance in a south-easterly direction from Kingsgate, is the Comstock Bismuth Company's mine. . . . . A sample of bismuth collected from the heaps gave on assay—

Metallic bismuth	35·6 per cent.
Fine gold, at the rate of	2 oz. 9 dwt. per ton.
Fine silver, at the rate of	9 oz. 16 dwt. per ton.

"Thus, again, we see that the bismuth ore contains gold. These veins are in granite, and distant about 200 yards from the slate formation.

"It is a somewhat remarkable feature that all the bismuth veins (eighteen) as yet found, occur in the granite within a short distance from the slate; and it is probable that on further examination of the country along the line of junction of the two formations other veins will be discovered. The bismuth lode in the Silent Grove Mine occurs under the same conditions, viz., in granite, close to its junction with altered slates; and it is of similar character to those described.

"I may here mention that about 12 miles north from Glen Innes, and about 1 mile east from the Tenterfield road, several bismuth and tin-bearing quartz veins have been discovered. These occur in a different manner from those at Kingsgate. They form irregular veins and masses of quartz, traversing a fine-grained micaceous felsitic rock, which is surrounded by altered sedimentary rocks. In one place this rock, for a length of about 100 yards and a width of 15 yards, is traversed by a net-work of quartz veins. A small hole has been sunk here, and the stone taken from it contains bismuth ores, tin ore (cassiterite), molybdenite, arsenical pyrites, and wolfram.

". . . . I do not consider that the vein-stuff there can be profitably worked for tin on account of the occurrence in it of so much wolfram; but for bismuth mining the prospects are encouraging, and the reefs should be further tested."

The Minister for Mines and the Hon. E. Vickery, M.L.C., each exhibited bismuth ores from the Kingsgate mines. Mr. A. Delaney exhibited carbonate of bismuth in felspathic veinstone from Gumble, near Molong. This ore yields about 3 per cent. of bismuth, and the locality is favourably spoken of by the Government Geologist for the occurrence of bismuth ores, as it closely resembles the Kingsgate country.

IX.—Iron, Manganese, Chromium, and Cobalt.

Important deposits of iron ore are found in close proximity to coal and limestone in several parts of the Colony. Furnaces, rolling mills, &c., have been erected at Eskbank, Lithgow Valley, for the conversion of pig iron into malleable iron. Hæmatite, magnetite, chrome, and other iron ores were shown in the mineral collection. The ore found at Mittagong, in the Southern District, contains about 66 per cent. of iron*. The late Rev. W. B. Clarke was of my opinion that the masses of iron ore in this district had been gradually deposited from springs discharging the ferruginous water with which they were charged into a swampy depression of the surface, and remarked that even now the deposit at Fitzroy retains, in part, its original position. Careful examination of the ore revealed the presence of portions of vegetable matter, and tubular cavities, which, no doubt, are the casts of the plants that grew in the swamps.

From the transmuted appearance of the sandstone and shale near the southern edge of this deposit, Mr. Clarke was of opinion that the springs might have been at one time hot. The igneous rocks of the Mittagong district being highly charged with iron, were regarded by the same gentleman as the source of the iron itself; the deposit arising from its decomposition probably took a very long period of quietude to produce a mass at least 27 feet thick, and covering a considerable area.

The process by which these deposits have been formed is still going on whereever a spring or flow of water traverses rocks containing iron, these chalybeate waters on exposure to the atmosphere, absorb oxygen, forming insoluble oxides of iron and liberate carbonic acid. Such springs can be readily recognized by the thin iridescent film on their surfaces, and the rust—oxide of iron—which covers their bottoms. Speaking of the deposits of iron ore at Wallerawang, Professor Liversidge says: †"They contain two varieties of iron—magnetite, or the magnetic oxide of iron, and the brown hæmatite or goethite—the hydrated oxide; then in addition to these there are the deposits of the so-called clay bands

* The Government Geologist in "Mines and Mineral Statistics," 1875 (p. 94), states that "so far as could be ascertained some 3,000 tons of calcined ore from the Fitzroy Mine (Mittagong) gave 2,894 tons of pig iron, which sold at an average for £6 per ton. The iron ore is said to be a very fine quality, but somewhat difficult to smelt."

† Minerals of New South Wales, 1888, p. 87.

which are interstratified with the coal-measures. These clay bands are not what are usually known as clay iron ores in England. They are brown hæmatites, var. limonite, while the English clay iron ores are impure carbonates of iron, which seldom contain much more than 30 per cent. of metallic iron, against some 50 per cent. contained by the hæmatites. A highly ferruginous garnet rock accompanies the veins of magnetite; this garnet rock is very rich in iron, and it will probably be found advantageous to smelt it with the other ores, not only on account of the large percentage of metal which it contains, but also on account of the increased fluidity it would impart to the slag." The approximate area of iron ore deposit is 1,400 square miles. The value of the iron raised to the end of December, 1887, amounts to £265,464.

The Minister for Mines exhibited a collection of samples of iron ores from the principal deposits in the colony; and about a ton from the Fitzroy Iron Mines, near Mittagong; and a similar quantity of chrome iron ore from Nundle, Peel River.

Large deposits of manganese oxide and chromite have been found, but they have not yet been systematically worked.

X.—Mercury.

Cinnabar (sulphide of mercury) was shown by the Minister for Mines, from Cudgegong, with samples of the drift in which it occurs. The Government Geologist, who inspected this locality* says, that it occurs in a water-worn quartz pebble drift, and red ferruginous clays, with irregular masses of brown ironstone. This drift deposit he describes as the remains of the old bed of the streams which in the Tertiary period flowed down the Cudgegong Valley, the present river channel having been subsequently eroded.

Mr. Waters, manager of a company, who prospected the deposit some time before, informed him that he sank a prospecting shaft 203 feet, when it was abandoned. He states that the cinnabar was found more or less through the drift, from the surface to a depth of 50 feet on to a false bottom, and that the deposit without cinnabar continued to 117 feet, when the true bed-rock (Devonian schists) was met with; but at 170 feet, when in black schists, he cut through a vein four inches thick, dipping south-west, and containing a little cinnabar. The cinnabar taken from here occurs usually in sharp angular pieces, from half-an-inch in diameter down to the size of fine dust, and pieces have been obtained several pounds in weight. Often the surface of the cinnabar is somewhat rounded, but this may be the original form, and not due to attrition. Perhaps the most important feature connected with the occurrence of the ore is, that the solid cinnabar is sometimes seen to gradually merge into, or impregnate the clay or

* Annual Report, Department of Mines, New South Wales, 1884, p. 152.

drift of the deposit in which it is found. This is, then, direct evidence that it has not been drifted by running water, like the water-worn pebbles and other material forming the old Tertiary lead, and that it has probably been derived from thermal water, which issued from the underlying Devonian rocks, and permeated the Tertiary deposit.

XI.—Tungsten.

Wolfram (tungstate of iron and manganese) and scheelite (tungstate of lime) were shown in the Minister for Mines' Collection, the former from Hogue's Creek, near Glen Innes, and Vegetable Creek, and the latter from Hillgrove, near Armidale, and Cordillera Hill, Tuena.

The Hon. E. Vickery, M.L.C., also exhibited wolfram from New England.

The Government Geologist mentions its occurrence in considerable quantity at Hogue's Creek, about twelve miles north of Glen Innes: and Mr. Geological-Surveyor David made the following report* on its occurrence in the Vegetable Creek Tin-field.

"An important vein of wolfram occurs in the Mole Table-land, 13½ miles north of Emmaville, in a direct line, but 21 miles distant by road. The point at which the reef was observed to be rich in wolfram bears west 36° south from the south-west corner of portion 407, parish of Rockdale, county Clive, one quarter of a mile distant, and lies just outside the boundary of this parish in the north-east corner of the parish of Flagstone, county Gough. The vein is, in places, from 10 to 12 yards wide, though probably not metalliferous throughout its entire width. Owing to the reef being partly covered over by the iron-stained sandy soil, it is impossible to ascertain by mere inspection the average width or length of its outcrop, though surface indications favour the supposition that the reef is a strong one. The strike is about N. 40° E. As far as I am aware, this reef has never been prospected, and it is situated partly on Crown lands. Wolfram also occurs at the Gulf main vein, Hail's Grampians, Lee's Gully, and the Planet vein, near the head of the Nine-mile Creek, parish of Wellington Vale, county Gough."

In 1881 the price of wolfram in England was £10 per ton. In 1882, the total quantity of wolfram raised in Cornwall, England, was 58 tons, which was sold at the rate of £12 17s. 7d. per ton. At the end of March, 1885, the value of wolfram in England, as I am informed by Mr. W. A. Dixon, F.I.C., F.C.S., was about £15 per ton. Scheelite has been found in small quantities at M'Donald's veins, on the Glen Creek, Vegetable Creek District; at Hillgrove, near Armidale, and at the Cordillera Hill Silver-mine, Tuena, a quantity from the latter was shown by the Cordillera Hill Silver-mining Company. The value of this mineral is about £40 per ton.

* Geo., Vegetable Creek Tin-field, 1887, p. 161.

XII.—Zinc.

The Minister for Mines exhibited specimens of sulphide of zinc (sphalerite) from New England. Mr. Geological-Surveyor David states that zinc has been found in some quantity in the Vegetable Creek District, in the Pye's Creek veins, the Little Plant vein, the copper vein, in Portion 85, Strathbogie North, at Hall's Grampians, and in small quantities in the M'Intire, Butler's Ottery's, and the Folkestone veins. The value of the ore is about £7 per ton.

Calamine (carbonate of zinc) is found associated with silver ores in the Broken Hill District, samples of which were to be seen amongst the exhibits from the Broken Hill Mines. It was discovered at Bredbo, in the Braidwood District, assaying 50 per cent. metallic zinc. A shaft was sunk upon it, but I understand that it pinched out. No workable deposits have yet been found.

XIII.—Diamonds and other Gems.

Diamond-mining in New South Wales is likely to become of much importance. Upwards of 50,000 diamonds have been obtained up to the present time, chiefly from the Tertiary drifts in the Bingera, Inverell, and Cudgegong Districts, besides a few from the neighbourhood of Mittagong, Wellington, and Uralla.

Geological maps of the diamond-bearing localities near Inverell and Bingera, by the Government Geologist and Mr. Geologist Surveyor Anderson, are published in the Annual Report, Department of Mines, 1887.

The principal minerals associated with the diamonds are gold, garnets, woodtin, brookite, magnetite, ilmenite, tourmaline, zircon, sapphire, ruby, admanatine spar, barklyite, common corundum, and a peculiar lavender-coloured variety of quartz, topaz, and nodules of limonite.

The largest diamond weighed 16·2 grains, or about 5⅝ carats.

A diamond from Bingera, used in one of the Government diamond drills, bored 1,267 feet through sandstone and conglomerate, without fracture.

The following extract is from the Government Geologist's report on the diamond-bearing formations in the Inverell district*:—

"The diamond bearing formations on the south side of Cope's Creek, where the Round Mount, Crown Jewel, Kohinoor, Red Hill, and Collas Hill Diamond Mines are situated.

"The diamond mines occur in old Tertiary river drifts, and in the more recent drifts derived from them. The former were once, and are partly still covered by basalt, which, in a molten state, flowed down the ancient valleys, and filled up the river channels. But the enormous denudation which has since eroded the present

* Annual Report, Department of Mines, New South Wales, 1887, p. 141.

deep valleys has swept away considerable portion both of the lava streams and of the old river deposits beneath them, leaving the remnants here and there in disconnected patches, resting on the older granite and altered sedimentary rocks. It is in one of these isolated patches that the above-mentioned companies, with the exception of that at Collas Hill, are working by sinking and tunnelling. The deposits are extensive, and have not yet been thoroughly prospected; the wash-dirt is from a few inches to 5 feet in thickness, and has yielded on an average from 2 to nearly 4 carats per load, averaging about four or five diamonds to the carat, though diamonds between 2 and 3 carats in weight each have been found. The returns kindly furnished me by mining managers show that about 23,000 diamonds weighing 5,151 carats, have been obtained during the last twelve months.

"The original matrix of the diamond in this country has not yet been conclusively ascertained. The Tertiary deposits are the oldest deposits in which the diamond has been found. Based upon this fact, an opinion was some years ago expressed by myself and others that the diamond may have been formed chemically in those drifts. Extended observations in the diamond-bearing districts would, however, lead me to suggest that if the Tertiary drifts be not the original matrix of the diamond, possibly its source may be in the metamorphosed Carboniferous or Devonian beds, where these have been intruded by granites and porphyries. Evidence of carbonaceous rocks having been subjected to great heat and pressure is presented in the rocks quarried for road metal at Pennant Hills, near Parramatta. If such condition be favourable for the occurrence of the diamond, this locality should be prospected."

Of the Bingera diamond deposits, Mr. Geological-Surveyor Pittman reported *:—

"The diamond drift, probably of Pliocene age, which is from 3 to 4 feet thick; is found capping small hills, the country since its deposition having been subjected to much denudation, which has almost entirely removed the basalt that once covered up this old river bed. The pebbles of the diamond drift vary in size from the size of a pea to several inches in diameter.

"The main dividing range forming the watershed between the rivers Gwydir and Horton, consists of altered slates and conglomerates of Siluro-Devonian age, with intrusive dykes of diorite, above which is another quartz pebble drift (probable Miocene) capped with older basalt which forms a table-land on top of the mountains. The banks of the river Gwydir are also covered with a coarse pebble drift, similar to that in which the diamonds occur, and covered in a few places with newer basalt, but this has been for the most part removed by denudation, and the river has subsequently cut its present channel. The evidence of the older basalt capping the drift on the range of mountains, indicates that this drift is of greater age than either the drift in which the diamonds have been worked, or that along the course

* Annual Report, Department of Mines, New South Wales, 1881, p. 141.

of the river, the two latter appear to junction, and were probably contemporaneous. It is reasonable to assume that diamonds will be found both in the drift along the banks of the Gwydir, and also under the basalt along the top of the mountain range, since the formation in which they have already been found, is an old river-bed leading from the drift on the top of the range and junctioning with the other drift on the banks of the Gwydir."

The following are the conclusions arrived at by Messrs. Thos. Davies, F.G.S., and R. Etheridge, junr., who, at the request of the Agent-General for the Colony, examined a parcel of 285 stones, forming an exhibit at the Colonial and Indian Exhibition, 1886* :—

"1. The diamonds of New South Wales in their physical character are more nearly allied to those of Brazil than any other country.

"2. They have been very largely sold in London as such.

"3. As regards colour they differ practically but little from those of other fields.

"4. The general absence of 'cleavage' and 'macles' is a point much in their favour.

"5. Stones of the rarer colour assumed by the diamond should be particularly sought for.

"6. The greater hardness of the New South Wales gems will probably raise the cost of cutting, but this will be compensated for by their extra 'brilliancy.'

"7. 'Boart' should be eagerly sought for.

"8. Detailed statistics of the area and thickness of drifts likely to prove diamondiferous, and the number hitherto found so, should be prepared officially.

"9. All auriferous drifts should be prospected for diamonds.

"10. The matrix of the diamond in New South Wales bears no resemblance to that at the Cape."

Samples of the diamond-bearing drifts from the Inverell and Bingera deposits were shown by the Minister for Mines.

The Sydney Diamond Company from their property, twelve miles south-east of Inverell, and close to Cope's Creek, exhibited 400 carats of the usual character of New South Wales diamonds. From this property also were shown samples of the pebble drift (tailings) consisting of rolled pebbles of quartz, agate, and chalcedony, and a few small topaz, and of the waterworm prisms of black tourmaline which is so characteristic an associate of the diamond in these deposits. Stream tin also occurs in the drift.

* Annual Report, Department of Mines, New South Wales, 1886, p. 42.

Mr. E. W. Bathurst, from the Round Mount Diamond-mine, fourteen miles from Inverell, made a most interesting display of blocks of the drift, as well as loose drift. In one of the blocks and in a small piece broken from them, a diamond in each case could be seen partly exposed. The drift is of a very friable nature and easily worked. A number of diamonds were included in the exhibit, several of which have been cut, and are exceedingly brilliant stones of excellent quality. Specimens of associated gems and minerals from the drift were displayed, viz., topaz, sapphire, &c., stream tin ore and rolled tourmaline; and fragments of fossil wood and loose stones from the surface.

The following particulars concerning this mine have been supplied by Mr. Bathurst:—Area, 150 acres. Average thickness of drift, three to five feet. 2,700 diamonds, weighing 700 carats, were obtained at a cost for wages of £150. 1,500 diamonds, weighing 500 carats, were obtained from forty loads of drift. 408 diamonds, weighing 101 carats, were obtained from seven loads of drift. Over 2,000 carats of diamonds were obtained during the preliminary prospecting of the mine.

The Malacca Diamond and Tin-mining Company exhibited diamond and tin-bearing gravel, quartz crystals, pebbles, &c., from their property in the Inverell District.

As illustrating the occurrence of gem-stones and their associations in the Colony, the splendid collection shown by Professor Liversidge, of the Sydney University, was especially interesting and valuable. It embraced diamonds (some of them most beautifully crystallized) from the Bingera, Inverell, Cudgegong, and Mittagong diamond deposits. Cut and uncut oriental emeralds, sapphires, topazes, zircons, and opals; specimens of the gem sand, drifts, and associated minerals from the above localities; from the Berrima and Uralla districts, and from New England generally. Specimens from the diamondiferous deposit at the Cape were also shown for comparison.

The following particulars of the occurrence of the diamond near Mittagong are taken from the catalogue of Professor Liversidge's specimens:—

"The diamonds are of very good colour and quality, but no large ones have yet been discovered. The deposits have a very great resemblance to those of Bingera, except that tourmaline and the nodules of limonite and magnesite do not appear to be present. . . . . . The deposit covers but a small area; it overlies and is surrounded by the Hawkesbury sandstone. It is not improbable that the gold and gems have been derived from the Carboniferous conglomerate."

Small samples of topazes, sapphires, zircons, spinels, &c., chiefly from New England, were included in the collection exhibited by Mr. Martin Isaacsohn, of Nundle.

XIV.—Alum.

Prior to the recent discovery of alum-stone at Bulladelah, its occurrence in commercial quantity was not known in the Colony; alunogen (hydrous aluminium sulphate) occurring as an efflorescence in certain caves, such as the Ben Bullen had been noted.

The Australian Alum Company exhibited alum crystals prepared from the alunite (sulphate of alumina) obtained from their property at Bulladelah. It occurs as an immense deposit forming the summit of a ridge about three-quarters of a mile long by half-a-mile wide, and rising about 1,000 feet above the level of Myall Creek, on which it is situated. Viewed from the creek it presents a massive outcrop resembling limestone. It yields from 60 to 80 per cent. of alum upon roasting, lixiviating, and evaporating. Myall Creek is navigable to vessels drawing five feet six inches, and its channel is shortly to be deepened by dredging. The company have erected extensive works for preparing the alum, which will shortly be placed on the market.

Mr. A. De Mestre exhibited specimens of alunogen from the Shoalhaven district. It is of common occurrence in shales, and argillaceous sandstones containing iron pyrites—especially if in coal regions. The oxididation of the pyrites affords sulphuric acid, which combines with the alumina of the shale and clayey sandstone.

XV.—Building Stones, Marble, Serpentine.

Almost every variety of building stone may be obtained in New South Wales. In and around the city of Sydney there are numerous quarries in the sandstone of the Hawkesbury formation. This sandstone, which for colour and texture can hardly be surpassed for building purposes, is the stone most commonly used in the construction of the public and private buildings in Sydney. A large collection of one foot, and six inch, cubes of sandstone from the different quarries at work, were exhibited by the Minister for Mines. Extensive deposits of marble, of Silurian and Devonian ages, occur in several places in the Colony. The black variety from the Marulan, and the white from the Cow Flat marble quarries, have been used in flooring the great hall of the Sydney University. The marble near Wallerawang is thus described by Mr. C. S. Wilkinson, L.S., F.G.S., Government Geologist, on his geological survey map of the Wallerawang and Bowenfels District:—

"Thick beds of coralline limestone of very pure quality. It forms a compact marble of various tints—white, cream, and dove-coloured, and sometimes with pink markings. It dresses well, takes an excellent polish, and may be obtained in blocks of almost any required size and quantity. Situated as it is, only 7 miles

from the Wallerawang railway station, it will be available for the iron-smelting works in the district, and will afford a source of large supply for the Sydney market. The limestone consists almost entirely of corals—*Favosites gothlandica*, *Favosites polymorpha*, *Lithostrotion*, and others, and molluscs as yet undermined."

The red marbles from the Tamworth District are very handsome when polished, and suitable for ornamental purposes. Several large polished slabs of the above marble as well as a number of tiles were exhibited by the Minister for Mines, and a very handsome black and white coralline marble was shown by Mr. J. Burns, from near Rockley.

Granite occurs in great abundance, and in every variety of texture and colour; it is used in Sydney for building and decorative purposes. Specimens from Moruya, Montagu Island, and Trial Bay were exhibited in the Mines collection.

Roofing slates of excellent quality have been obtained in the Goulburn, Bathurst, and Gundagai Districts.

Fine-grained siliceous sandstone, very suitable for flagging purposes, occurs in the Orange, Burrowa, and Narrandera Districts.

Serpentine of pale and dark green colour, sometimes mottled with white, forming a fine ornamental stone, can be obtained in quantity in the Bingera, Grafton, and Young Districts. Polished samples of excellent quality were shown from Bingera.

Syenite from Mittagong was exhibited; it was used in the construction of the piers of the railway bridge over the Hawkesbury River, as being most suitable for resisting the destroying action of sea-water.

The following particulars have been kindly supplied by Mr. W. M. Lewis, Clerk of Works, East Maitland, concerning the collection of building stones exhibited from the Hunter River District; and are the results of practical experience:—

"The Clarence Town sandstone exhibited is very strong and durable; retains its colour; withstands the effect of sea air. Blocks upwards of 10 tons each were used in the erection of the buildings near West Maitland for the Hunter River Water Supply; it was also used in the erection of the Court-house at Dungog, and in the additions to the post office at Newcastle, and I am not aware of a single stone in any of the buildings in which it has been used showing the slightest signs of decay.

"The East Maitland stone has the appearance of durability. It was used in the erection of St. Peter's Church at East Maitland.

"The Wollombi pink sandstone is a good durable stone easily wrought and retains its colour; it was used in the erection of the Public School and master's dwelling at Wollombi.

"The light brown sandstone from the same place is of similar quality to the pink, and as durable; used in the masonry of the Court-house, and would, if it could be conveyed by rail to Newcastle, Maitland, Singleton, &c., do away with the delay which contractors and others are now put to in having to wait time after time for a supply from Sydney, which is usually conveyed by water in sailing vessels.

"Some of the Morpeth stone is very durable, but care must be taken to reject any of a blue or grey tint, which on exposure turns green, and peels off in flakes; it was used some thirty years ago in the construction of bonded stores at that place, and shows no signs of decay.

"The Ravensfield stone is used in the erection of buildings in the Maitland district; it is good stone for ornamental work if kept dry and well above the ground, and care taken to avoid all yellow tints or streaks in the stone, which, if exposed to a north or westerly aspect, will decay.

"The Paterson stone is similar to Ravensfield stone; colour, grey and light brown, the latter preferred, it also requires care in selecting; used upwards of twenty years ago in the balustrades and other ornamental works at the Court-house, Paterson, and within the last few years in other public buildings at that place.

"Of Muswellbrook stone, some very durable specimens can be seen in the Court-house, Post and Telegraph Office, and Commercial Bank at that place; also in upper part of base course at Court-house, Scone. That obtained from the Grass-tree Quarry, and spotted with bran-like marks throughout, I have always found very durable.

"Some of the Greta stone is very durable, but requires great care in selecting; good specimens are to be seen in the Court-house and Lock-up at Branxton, near Greta.

"The Rutherford stone is similar to Ravensfield, but of lighter colour, and requires care in selecting."

Resting in the undulations of the surface of the Sydney (Hawkesbury) Sandstone is a lacustrine deposit of fine clays and shales, known as the Wianamatta Series; from these are manufactured bricks, tiles, terra-cotta, and pottery, of the best quality, for the supply of Sydney and its suburbs. Samples of the latter with the raw clay and shale were shown by the following:—Clyde Pottery (G. M'Arthur); Petersham Brick Works (Elphinstone & Wilson); Ashford Brick Works (Tabrett & Draper); Beulah Brick Works (Bakewell Bros.); Eureka Pottery (W. J. Carter); The Warren Brick Works (E. Curlewis);

Frogmore Brick Works (Despointes Bros.); Newtown Steam Brick Works (Goodsell Bros.); J. T. Gibson, Gore's Hill, North Willoughby; G. Cochrane, Mowbray Park, North Willoughby; R. Cook, Marrickville; J. Paul, Waterloo; F. Wheeler, Riverstone; Cumberland Pottery (F. Liebentritt); Harber & Co., St. Peters.

From a shaking bog near Tumut, Mr. Travers Jones, M.P., exhibited a fine china clay, the following analysis and comparison made by Mr. J. C. H. Mingaye, F.C.S., between it and clays of known worth will be of interest:—

	Chinese.	St. Zrieux.	Cornish.	New South Wales.
Silica	50·5	46·37	46·32	44·46
Alumina	33·7	34·95	39·74	37·85
Oxide of Iron	1·8	1·26	0·27	A minute trace.
Lime	......	......	0·36	0·22
Magnesia	0·8	Trace.	0·44	Trace.
Potash	1·9			
Soda		2·40		1·18
Water	11·2	12·62	12·67	16·29

XVI.—Coal.

The approximate area of the Carboniferous strata in New South Wales is estimated at 23,950 square miles. The principal coal-beds exist along the coast to the north and south of Sydney, and on the Great Northern, Great Western, and Great Southern Railway Lines. The mines first opened are situated in the immediate vicinity of Newcastle; and it is from there that the Colony obtains its largest supply. In many districts the coal crops out on the face of the hills; and can be cheaply got by driving tunnels. The coal-shipping facilities at Newcastle are by staiths and steam and hydraulic cranes. Full descriptions of the various coal-seams worked in New South Wales have been given by Mr. John Mackenzie, F.G.S., Government Examiner of Coal-fields, in the Annual Reports of the Department of Mines, and in the *Mineral Products, &c., of New South Wales*, 2nd edition, 1887. Writing of the Upper Coal Measures in the Western District the Government Geologist says:—"They are 480 feet thick, resting conformably on the marine beds of the lower coal-measures, and overlaid by more than 500 feet of Hawkesbury sandstone. The seam worked, which is 10 feet thick, is the lowest in the series, and lies about 25 feet above the marine beds, and is the same seam worked by the Bowenfels, Eskbank, Lithgow Valley, Zig Zag, and Vale of Clwydd Collieries. This seam of coal crops out on the surface of the railway

line near Bowenfels. It dips at a low angle of 3 to 5 degrees to the north-east, and is therefore easily worked; and as it passes under the vast extent of mountain ranges to the north and east it will be inexhaustible for generations to come." The No. 1, or uppermost seam, is worked at the Katoomba and Hartley Vale Collieries, and has been opened out near Mount Victoria, Mount Wilson, and between the Zig Zag and Mount Clarence. The production of coal has increased very rapidly of late years. In 1833, 328 tons were raised, and in 1887, 2,922,497 tons. Several seams of petroleum coal have been found, and the coal from two of them is retorted for the manufacture of "kerosene oil." Their thickness varies from a few inches up to 5 feet. The Hartley shale yields 130 gallons of crude oil, or 18,000 cubic feet of gas per ton, with an illuminating power equal to forty candles. The total production of coal to 31st December, 1887, was 39,892,862 tons, of the value of £19,698,831, and of petroleum coal, 481,252 tons, of the value of £1,083,174. Sections and samples of the coal-seams worked in the Northern, Western, and Southern Coal-fields were exhibited.

NEWCASTLE HARBOUR, AND ITS FACILITIES FOR SHIPMENT.*

"Newcastle, in the county of Northumberland, the trade of which is second only to that of Sydney, owes its great commercial importance to the different coal-mines which have been opened out close to and within 32 miles of the harbour.

"On the south or town side of the harbour there is a continuous line of wharf 3,600 feet long belonging to Government, 1,470 feet of which is occupied by four steam cranes for the shipment of coal, 660 feet for cargo berths for deep draught vessels, 500 feet reserved for the Sydney passenger steamers (owing to the increased size of the new boats put on the Sydney passenger service this wharf has lately been considerably increased in length and width), 400 feet is used as a general cargo wharf, including a lumber berth for loading vessels with timber, and 570 feet for shipment of coal with four shoots. The whole length of the wharf is lit up with gas.

"At Bullock Island, on the western side of the harbour, a substantial timber Government wharf, 6,293 feet in length, has been constructed along the face of what was formerly known as the ballast dyke; 4,493 feet of this wharf is set apart chiefly for the shipment of coal. The loading is performed by hydraulic cranes, of which there are eight erected and four in course of construction—six being 15-ton cranes, capable of shipping 1,000 tons of coal each in twelve hours, and two 25-ton cranes, which can be used for discharging heavy machinery, &c., when necessary. Ships of the largest class can load under the hydraulic cranes, and proceed to sea through deep-water channels recently dredged. There are also three 50-foot ballast jetties 200 feet apart. It is proposed to spend immediately a

* Descriptions of the seams of coal worked in New South Wales; by John Mackenzie, F.G.S., Examiner of Coal Fields. *Mineral Products of New South Wales, 1887, 2nd Edition,* p. 98.

sum of £50,000 to further increase the shipping facilities at Bullock Island. Some 2,000 feet of wharf will be erected as a commencement of a 90-acre basin inside the present wharf, which (basin) it is intended to dredge to a depth of twenty-five feet, where vessels will be able to lie in slack water; and the whole will be lit up with the electric light. The remainder of this wharf is used by vessels discharging ballast, copper and other ores, or general cargo. A branch double line of railway connects the wharf with the Great Northern Railway, and along the back of the wharf is laid a very extensive system of sidings and standage room for working the coal traffic. Each crane has a full and empty line of railway, and lifts the coal waggons of six to ten tons, and slewing them round, discharges the coal into the hold of the ship.

"At Stockton, on the northern side of the harbour, a Government wharf, 600 feet long, with two 15-ton steam cranes, capable of shipping 1,000 tons of coal each in twelve hours, is completed.

"In addition to these Government cranes, the Australian Agricultural Company have three large private shoots, at which 1,200 tons of coal can be loaded in 12 hours. Vessels loading from them can discharge their ballast on to the company's ballast wharf, lying safely alongside at a draft of eighteen feet six inches and upwards. They load vessels under their shoots to a draft of nineteen feet six inches; and the Waratah Coal Company have two shoots at Port Waratah capable of shipping 600 to 700 tons in twelve hours.

"The estimated present capabilities for shipment of coal at the above-mentioned places in Newcastle Harbour are about 16,000 tons in 12 hours, which, when the additional six hydraulic cranes at Bullock Island, and the two at Stockton, are erected, will be increased to 24,000 tons.

"The quantity of coal shipped in 1886 to foreign and intercolonial ports was 1,544,094 tons, valued at £828,189; and the largest quantity of coal taken by a sailing vessel was 3,320 tons, and by steamer, 3,203 tons.

"There are forty collieries at work and opening out in the Newcastle District, which raised 2,178,116 tons of coal, valued at £1,084,555.

Illawarra District and its Facilities for Shipment of Coal.

"The Wollongong Harbour and Basin is situated forty-five miles south of Sydney Harbour, and at low tide there is a depth of thirteen feet of water at its entrance and alongside the wharf, where there are three cranes capable of shipping 1,800 tons of coal per hour. The Belmore Basin has a depth of seventeen feet of water at its eastern side, where there are four shoots each capable of shipping 100 tons per hour; but as only two vessels can load there at the same

time the largest quantity of coal shipped by them is 200 tons per hour, or 2,000 tons per day. The largest steamships which have coaled at the harbour are the 'Barrabool' and 'Wentworth,' drawing 15½ feet of water, and carrying 900 tons, and the largest sailing vessel took away 700 tons.

"In addition to the Government appliances for shipment of coal at Wollongong the Coalcliff, Bulli, North Illawarra, and Mount Kembla companies have jetties of their own, from which coal is sent by steam colliers to Port Jackson and elsewhere.

"The Coalcliff jetty has a depth of eighteen feet of water at high tide, and fourteen feet at low tide, and can ship 100 tons per hour. They have two steam colliers carrying 250 tons each; and the greatest quantity of coal shipped per day has been 520 tons.

"The Bulli jetty has a depth of twenty-six feet of water at the shoots, which are capable of discharging 120 tons of coal per hour each, into steam colliers, of which they have three. The largest carries 700 tons, and the others 500 and 300 respectively.

"The North Illawarra Coal Company have just completed a fine jetty, 870 feet in length, which has twenty-six feet of water at their shoot at high tide; and they can ship about 120 tons per hour.

"The Mount Kembla jetty has a depth of twenty-six feet of water at their shoot at low tide, and the company can ship about 120 tons per hour therefrom, and have sent away 1,472 tons in a day. The largest ship that has loaded from it is the 'Titus,' with 1,000 tons of coal, and drawing seventeen and a half feet of water.

"The coal raised in the Illawarra and Southern districts, in 1880, was 240,211 tons, and in 1886, 370,830 tons, or an increase of 130,629 tons in the last six years.

THE WESTERN COLLIERIES AND THEIR RAILWAY AND SHIPPING APPLIANCES.

"All the Western collieries are adjacent to, or within a short distance of, the Great Western Railway, and they have for many years had the supplying of coal to the Government railway locomotives, &c. Their coal meets with a ready sale for manufacturing, household, and other purposes in all the suburban and inland towns, and large quantities of slack are sold for brick and tile making.

"Appliances will shortly be completed, and ready for use, for the shipment of coal at Darling Harbour, Sydney, at its junction with the Great Western Railway.

"The Western collieries have almost doubled their output in the last six years, the quantity raised by them in 1880 being 146,960 tons, and 281,229 tons in 1886.

TABULAR STATEMENT of Composition of New South Wales Coals.

COALS OF NEW SOUTH WALES MINED FOR EXPORT.	Water.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Analyst.
Northern District. *								
1. Ferndale Colliery, Newcastle; ash, buff-coloured	2·10	36·22	57·24	3·84	0·60	1·296	61·08	Dixon.
2. Newcastle Wallsend Colliery, near Newcastle; ash, reddish	2·29	34·21	58·60	4·28	0·62	1·347	62·88	,,
3. ,, ,, ,, ,, ,, ,, pinkish	2·75	34·17	57·22	4·64	1·22	1·333	61·86	Liversidge.
4. Australian Agricultural Co.'s Colliery; ash, white and heavy	2·22	32·60	57·52	5·35	1·33	1·297	62·87	,,
5. ,, ,, ,, ,, ,, reddish	1·65	35·45	57·84	4·44	0·62	1·286	63·28	Dixon.
6. Co-operative Colliery, Plattsburg; ash, reddish	2·45	34·38	58·24	4·20	0·73	1·310	62·44	,,
7. Waratah Colliery, near Newcastle; ash, buff-coloured	2·45	38·16	54·12	4·64	0·63	1·293	58·76	,,
8. ,, ,, ,, ,, reddish	2·21	36·70	55·82	4·15	1·12	1·303	59·97	Liversidge.
9. Newcastle Coal-mining Co.'s Glebe Colliery; ash, buff-coloured	2·14	33·36	59·16	4·76	0·58	1·283	63·92	Dixon.
10. New Lambton Colliery, near Newcastle; ash, reddish	2·61	30·62	59·56	6·72	0·49	1·291	66·28	,,
11. Minmi Colliery, Hexham; ash, reddish	2·59	33·87	56·49	5·61	1·44	1·280	62·10	,,
12. Redhead Coal Company; ash, grey	2·09	33·48	57·04	6·84	0·55	1·325	63·88	,,
13. Anvil Creek Colliery; ash, white	1·74	41·10	47·90	7·80	1·46	1·323	55·70	Liversidge.
14. Greta Colliery; ash, buff-coloured	2·25	39·21	54·41	2·72	1·41	1·287	57·13	,,
Southern District.†								
1. Mount Keira Colliery; ash, white	1·15	23·51	64·65	9·70	0·99	1·379	75·35	Liversidge.
2. Mount Kembla Colliery; did not coke; ash, white	1·50	19·74	67·18	10·72	0·86	1·363	None	,,
3. Illawarra Coal Company's Colliery; ash, grey	0·70	22·04	68·08	8·76	0·42	1·354	76·84	Dixon.
4. Coal Cliff Colliery; coke not very perfect; ash, greyish	0·86	18·22	69·84	10·80	0·28	1·378	80·64	,,
5. Osborne Wallsend Colliery, Wollongong; ash, grey	1·19	21·07	66·92	10·20	0·62	1·404	77·12	,,
6. Bulli Colliery; ash, grey	0·65	21·65	65·86	11·28	0·74	1·361	76·96	,,
7. Coal Cliff Colliery	1·61	19·68	68·08	10·28	0·35	1·372	78·36	,,
Western District.‡ *Coals mined chiefly for local use.*								
1. Lithgow Valley Coal Co.'s Colliery; coke hard; fairly lustrous; ash white.	1·95	34·18	52·34	10·12	1·41	1·329	62·46	Liversidge.
2. Lithgow Valley Coal Company's Colliery; ash, grey	2·24	28·48	58·80	9·68	0·80	1·340	None	Dixon.
3. Eskbank Colliery. Coal, rather dull; ash, greyish-white	2·70	28·78	57·88	9·88	0·76	1·329	None	,,
4. ,, ,, ,, ,, ,, coke, tender; ash, white	2·00	33·55	49·97	12·91	1·57	1·355	63·18	Liversidge.
5. Vale of Clwydd Colliery. Coal, rather dull; ash, grey	2·15	35·02	52·36	9·72	0·75	1·328	None	Dixon.
6. ,, ,, ,, Coke, compact, fairly lustrous; ash, greyish-white	2·10	33·35	53·38	9·80	1·37	1·323	63·18	Liversidge.
7. Bowenfells Colliery. Ash, white and dense	2·36	28·35	56·54	11·40	1·35	1·399	None	,,
8. Katoomba. Coal, fairly bright and hard; coke, soft and dull; ash greyish-white.	2·90	25·82	61·34	9·26	0·68	1·326	70·60	Dixon.
9. Katoomba. Coal, very dull-coloured; no true coke; ash, greyish-white	2·25	26·28	60·84	10·04	0·57	1·400	None	,,

*The coals of this district are all very similar in appearance, being firm, and show a bright laminated structure, with traces of mineral charcoal; they are all highly bituminous, cake strongly in the fire, and yield bright, hard, sonorous cokes.

† The coals of this district are characterized by a somewhat dull colour, but are firm and strong. They may be classed as free-burning bituminous, as although they do not cake in the fire they are readily coked in an oven.

‡ These coals are properly non-coking bituminous; although they all coke when fresh from the pit, they lose this property by exposure; they are compact, and vary in appearance from fairly bright to dull-coloured.

TABULAR STATEMENT of Composition of New South Wales Coals—*continued.*

	Water.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Analyst.
COALS OF NEW SOUTH WALES NOT WORKED, OR WORKED FOR LOCAL CONSUMPTION ONLY.								
1. Northern District, Russell's. Coal streaky, irregular, bright and dull; coke, firm, bright, lustrous; ash, pink.	1·85	44·09	49·95	2·70	1·41	1·274	53·65	Liversidge.
2. Teralba. Coal, bright, stained with oxide of iron; coke, fairly bright; ash, reddish.	4·65	32·84	52·68	8·16	1·67	1·350	60·84	Dixon.
3. Teralba. Coal, bright; coke, dense, bright, and lustrous; ash, grey	3·81	30·22	54·44	8·52	3·01	1·290	62·96	"
4. Lake Macquarie Coal, fairly bright; coke, hard and dense, moderately bright; ash, white.	3·65	31·93	54·66	8·82	0·94	1·34	63·48	"
5. Dymock's Jamberoo. Coal, firm and compact, non-coking; ash, grey	1·50	20·22	56·56	20·70	1·02	1·455	None	Liversidge.
6. Berrima. Coal, somewhat tender; coke, bright, lustrous, much swollen; ash, white.	1·70	32·78	53·84	10·40	1·28	1·364	64·24	"
7. Berrima. Coal, somewhat tender; coke, soft and dull-coloured, much swollen; ash, greyish.	1·90	21·17	57·67	18·25	1·01	1·37	75·92	Dixon.
8. Berrima. Coal, rather dull-coloured; much swollen, fairly lustrous and hard; ash, white.	1·21	19·95	41·30	36·56	0·98	1·56	77·86	"
9. Berrima. Coal, rather dull-coloured; coke, little swollen, dull and friable; ash, white.	1·26	15·61	48·34	33·92	0·87	1·51	82·26	"
10. Berrima. Coal from Wingecarribee River; coal, hard and bright with reddish incrustation; coke, hard, fairly lustrous; ash, white.	1·41	30·20	53·15	13·46	1·78	1·355	66·61	"
11. Berrima. J. J. O. Atkinson; coke, swollen and fairly bright; ash, greyish white.	1·26	26·61	62·28	9·40	0·45	1·408	71·68	"
*Western District.**								
12. Rylstone, near Mudgee, Stewart, Taylor, & Co. Coal, dull, with bright fracture; coke, strong, fairly bright; ash, greyish white and bulky.	7·70	36·42	51·48	9·76	0·64	1·300	61·24	Dixon.
13. Northern District, Rix Creek, Singleton. Coal, bright, but rather tender, slightly caking.	2·8	37·00	54·0	5·6	0·51	...	59·6	Latta.

* These coals are properly non-coking bituminous; although they all coke when fresh from the pit, they lose this property by exposure; they are compact, and vary in appearance from fairly bright to dull-coloured.

From a report by W. A. Dixon, F.C.S., F.I.C., published in "Mineral Products of New South Wales;" by Harrie Wood, Under Secretary for Mines, 1887.

"A Block of Coal was exhibited from the Borehole coal-seam, worked by the Australian Agricultural Company from under their 2,720 acres of freehold and leasehold land, at a depth of 200 feet at their Hamilton pit, about 2 miles by their railway from Newcastle Harbour. It averages 10 feet 6 inches in thickness, it is very free from faults, lies very regular, dips about 1 in 40 south-east, and has an average specific gravity of 1·28. This Company's appliances for haulage, drainage, and ventilation of the mine, comprise all the latest improvements; and their's is the only colliery that has a Guibal Fan in place of an underground furnace for ventilation purposes. 387,074 tons of round and small coal valued at £184,750, were raised in 1886; and 803 men and boys were employed underground, and 172 aboveground daily, when the colliery was at work; and the total quantity of air produced in the mine by the Guibal Fan is from 90,000 to 112,000 cubic feet per minute. They have appliances for an output of 1,600 tons of round and small coal per day of eight and a half hours. *

"A full section was exhibited of the Coal-seam worked by the Burwood Coal-mining Company at Little Redhead, about five miles by the Company's Railway from the Newcastle Harbour. This colliery was only commenced to be opened out by the present company in September, 1883, on 1,000 acres and upwards of leasehold land, the property of E. C. Merewether, Esq. On December 10, 1884, a winding shaft 14 feet 6 inches in diameter was commenced to be sunk to the Borehole coal-seam by Mr. Simpson, which was passed through at a depth of 266 feet on 10th May following. Their pithead and all other arrangements in connection therewith contains all latest improvements, such as detaching hooks to their cage fixings, steel slips, waggons, &c.; and have present appliances equal to an output of 800 tons of round and small coal per day of eight and a half hours. The coal-seams dip about 1 in 40 to the south; and the Borehole coal is similar in quality to that worked at the Newcastle Coal Company's Colliery adjacent thereto. 72,566 tons of round and small coal, valued at £39,911, were raised in 1886; and 225 men and boys were employed underground, and 47 aboveground daily when the pit was working.

"The Borehole coal-seam worked at the before-mentioned Newcastle collieries represents one and the same seam. It is a bright bituminous caking coal of first-class quality for steam, household, coking, and smelting purposes, a good gas coal, and there has as yet been found no coal equal to it in New South Wales for all these general purposes. The No. 2 or Burwood seam, worked at the South Waratah, New Lambton, and Burwood Collieries has, so far, proved to be the next best in quality in the Newcastle District, and a considerable quantity of it was sold from these collieries in 1885.

* Compiled from "Descriptions of the Seams of Coal worked in New South Wales," by John Mackenzie, F.G.S., Examiner of Coal-fields.—*Mineral Products of New South Wales, 1887, 2nd Edition.*

"A section of coal was exhibited from the Borehole Coal-seam, worked by Messrs. Brown, at Brown's Duckenfield Collieries, six miles by rail from the mine to shoots erected alongside the Hunter River, where vessels of large size are brought from Newcastle Harbour to be loaded with coal, a distance of about twelve miles. The property consists of over 3,000 acres, and the coal is wrought out from adits driven into the hill side. Its specific gravity is about 1·28, and the coal-seam dips slightly to the south-west. They ship coal also at Newcastle Harbour, and raised 227,798 tons of coal, valued at £110,237, in 1886, and employed 501 men and boys underground and 105 aboveground daily when the colliery was at work. They have four furnaces in their two collieries about one mile apart, producing in their mine from 85,000 to 90,000 cubic feet of air per minute.

"A block of coal was shown from the Greta Colliery, near Newcastle, being a section of the coal-seam sunk to, and now being worked by the Greta Coal Company, on 2,136 acres of leasehold land at the Greta Colliery B pit, at a depth of 450 feet from the surface. The coal lies very regular, is very free from faults, and dips about 1 in 6 to the west. The shaft is fifteen feet in diameter, and is fitted up with all necessary appliances for lifting and despatching large quantities of coal per diem. When sinking the pit a great number of Carboniferous fossils, such as *Spirifera*, *Producta*, *Conularia* and *Orthoceras* were found; and a *small patch* of rich petroleum oil cannel coal, or boghead mineral, has been found and worked out from under the property. Inflammable gas, in small quantities, occurs in this coal. 98,282 tons of round and small coal, valued at £49,141, were raised in 1886; and 254 men and boys were employed underground, and 49 aboveground daily, when the colliery was at work.

"A section of Coal was exhibited from the Borehole coal-seam, where sunk through by the Hetton Coal Company, at Bullock Island, adjacent to the wharf, the steamer cranes fronting the Newcastle Harbour. It was cut at a depth of 237 feet from the surface, by a shaft 15 feet 10 inches in diameter, lined with cast-iron tubing for a depth of 180 feet from the surface. The sinking commenced 27 November, 1885, and was completed 19 March, 1887. The coal-seam had a total thickness (including bands) of 22 ft. 6 inches. It is of excellent quality, suitable for house-fire, steam, gas, blacksmith, and coking purposes. A compound winding engine with two 26-inch cylinders and a 54-inch stroke, three boilers 6 feet in diameter and 34 feet long. Tangye pumps with an air compresser to work them instead of steam, a substantial head-gear, and three screens, &c., have been erected, and the company anticipate raising large quantities of coal during 1888.

"A small block of coal was exhibited from the New Lambton Colliery C pit, Newcastle—opened out in 1884 by Messrs. Dibbs and Brown, on 640 acres of their 1,225 acres of New Lambton Colliery freehold land, situated near Adamstown,

and about 5 miles by their railway from the Newcastle Harbour. The Borehole coal is wrought out on the long-wall system at a depth of 243 feet from the surface, and the Burwood seam is worked from an adit. They raised from their New Lambton, New Duckenfield, and New Lambton Coal-pit collieries 71,370 tons of coal, valued at £33,454, in 1886, and employed 206 men and boys underground, and 83 aboveground daily, when the colliery was at work.

"A block was exhibited from the Borehole coal-seam, opened out on the Newcastle Wallsend Coal Company's 9,000 acres of freehold land at Dark Creek, near Wallsend, situated about 6½ miles from the Newcastle Harbour.—Eight feet in thickness is wrought out for a distance of over 1 mile south of their Dark Creek adits, at which place it commences to get thinner, and deteriorate, as it extends further south in the property. It is very free from faults, lies very regular, and dips about 1 in 60 south-west and south. The coal is brought to the surface through adits, near the entrance of which there are three stationary engines that draw it in miners' skips of 12 cwt. each, up slight inclines, on to the landing-stage erected alongside the company's railway, where they have appliances for despatching 2,200 tons of round and small coal per day of eight and a half hours. 483,884 tons of round and small coal, valued at £240,000 11s., were raised in 1886; and 940 men and boys were employed underground, and 180 aboveground. They have three furnaces producing in their mine from 200,000 to 205,090 cubic feet of air per minute.

"A block of coal was shown from the Borehole coal-seam, worked by the Newcastle Coal-mining Company, on 1,400 acres of land leased from E. C. Merewether, Esq., at the Glebe, 2½ miles from the Newcastle Harbour by rail, and found at a depth of 303 feet from the surface.—This colliery was opened out and the coal won by the late J. Winship, Esq., who for fifteen years was colliery viewer for the Australian Agricultural Company, and resigned his appointment with them to invest in and open out this colliery. Their haulage, drainage, and ventilation arrangements are all that could be desired. The coal lies very regular, is very free from faults, and dips about 1 in 40 south. 183,573 tons of round and small coal, valued at £83,181, were raised in 1886; and 400 men and boys were employed underground, and 93 aboveground. They have present appliances for an out-put of 850 tons per day of 8½ hours, and when the pit-top, &c., arrangements are shortly completed at their new pit, it will be largely supplemented.

"A small block of coal was exhibited from the Waratah Colliery at South Waratah. A township near the mine, called Charlestown, has sprung up since the opening out of these coal-seams. The Burwood coal-seams, seven feet six inches in thickness, about five feet of which is wrought, is the one they are now working at the Charles' pit, at a depth of 250 feet from the surface. The pit is 16 feet in diameter, and the head-gear engines, pumping apparatus, &c., are all of the best construction. It dips about 1 foot in 40 to the south, is worked on the long-wall

system, and is very free from faults. 7,753 tons of round and small coal, valued at £3,774, were raised in 1885; and 40 men and boys were employed underground, and 38 aboveground, daily, when the colliery was at work. No coal was wrought from this seam in 1886.

"A full section of coal was exhibited, showing thickness of the coal-seam worked at the West Wallsend Colliery, near Newcastle.—The Borehole seam has, with bands, a workable thickness of 5 feet 4¾ inches, on the West Wallsend Coal Company's property. The winding shaft is fifteen feet in diameter, and 492 feet in depth; the furnace shaft is ten feet in diameter, and 492 feet in depth. The colliery is situated in the Parish of Teralba, County of Northumberland, and will be fourteen miles by rail from the Newcastle Harbour when their branch line of about five miles in length has been constructed to the Government railway, near the Teralba station. Two coupled 25-inch cylinder winding engines, a conical drum ten feet to twelve feet in diameter, four boilers five feet six inches by thirty-three feet, and an iron head-gear, &c., have been erected, and when the railway line, now in course of construction, is completed, it is intended to ship coal to Newcastle. The coal is suitable for house-fire, steam, gas, blacksmith, and coking purposes.

"A block of coal and a number of remarkable concretions of coal were exhibited from the Stockton Colliery, Newcastle.—In March, 1885, the Stockton Coal Company, with great success, under the able management of Mr. Rossiter, civil engineer sank through the Borehole coal-seam 29 feet 7 inches in thickness, at a depth of 335 feet 6 inches, on their leasehold land at Stockton, adjacent to the Stockton wharf, the Hunter River, and harbour of Newcastle. Iron cylinders, fifteen feet in diameter, made of cast-iron 1½ inch in thickness, and formed of rings five feet six inches in depth, weighing about eight tons, were sunk by pressure by Mr. Rossiter, to hard rock, to a depth of eighty-four feet, and from there to the bottom of the shaft he sunk through a 4-feet 6-inch coal-seam, and the yard coal-seam two feet only in thickness, with conglomerates, hard grey post (rock) and shales between them and the Borehole coal-seam. The machinery, &c., erected, consists of two 60-horse power coupled horizontal winding engines, a 45-horse power condensing engine, driving an eight-inch pump, two shell boilers forty feet long and six feet six inches in diameter, poppet-head, pit-head, &c. Screens, tram-way, and wharf are now completed, and the Company are in a position to raise large quantities of coal. The coal-seam is of excellent quality, is intersected with dykes near the pit bottom, and varies in thickness. In one portion of the mine they work the upper part of the seam of coal, above the six feet six inches of shale, and in another the lower or nine to ten feet of coal. It has a south-easterly dip; and 84,495 tons of round and small coal, valued at £40,121, were raised in 1866; and 182 men and boys were employed underground, and 40 aboveground daily, when the colliery was at work.

"Coal core was exhibited by the Young Wallsend Coal-mining Company from their property near Newcastle.

"Coal was exhibited from the coal-seam sunk through by the Singleton Colliery Company, near Rix's Creek and Singleton. The company have constructed a tramway over a mile in length to connect the mine with the Great Northern Railway. Six feet nine inches in thickness is the portion worked; it is a bituminous coal, suitable for steam, household, gas, smelting, blacksmith, and coking purposes. The dip is about 1 in 12 to the north-west. They raised 8,920 tons of round and small coal, valued at £4,695, in 1886.

"Coal was also exhibited from the Rosedale Colliery, Camberwell, Great Northern Railway, 55½ miles north of Newcastle.

"A block of coal was exhibited showing thickness of seam at the New Anvil Creek Colliery.—Being a section of the coal-seam worked at Anvil Creek, adjacent to the Greta Colliery and the Great Northern Railway. It is thirty-two miles by rail from the Newcastle Harbour, and dips about one in nine westerly. It is identical with the seam worked at Greta.

"Coal and shale were exhibited from Prior's property, parish of Black Jack, county Pottinger, near Doughboy Hollow.—This coal-seam is six feet ten inches thick, of excellent quality could be cheaply wrought from adits, and a tramway could be easily constructed to the North-western Railway line, a distance of about seven miles.

"A block of coal was exhibited from the Bulli Colliery.—From a seam seven to eight feet in thickness of clean coal, free of bands, an average specific gravity of 1·36, and dipping about 1 in 30 to the north-west, on the Bulli Company's 2,628 acres of freehold and leasehold land, situated at Bulli, about eight miles north of Wollongong harbour. The coal-seam outcrops at a height of 350 feet above sea-level, in the Illawarra ranges, fronting the Pacific Ocean, where adits are driven into it. It is situated one mile from the Illawarra railway, now constructed, and an incline and locomotive tramway, two miles long, conveys the coal from the mine to the Bulli Company's jetty, where steam colliers come alongside and take away the coal. They raised, in 1886, 99,923 tons of round and small coal, valued at £22,457, and employed 276 men and boys underground, and 95 aboveground daily when the colliery was at work.

"A full section was exhibited of the coal-seam worked at the South Bulli Colliery This company's property is situated between, and immediately adjoins, the properties of the Mount Kembla Coal-mining Company and the Mount Keira (Osborne—Wallsend) Colliery, and contains 7,000 acres. This section included the floor of fire-clay, and the roof, both being cut out with the coal. The coal-seam is

from seven to eight feet in thickness, and is entirely free from bands. The coal-seam is 700 feet above sea-level, and has about 600 feet of cover. It is equal in quality to any steam coal in the Southern Coal Field. Mr. Wm. Wiley, Post Office Chambers, Pitt-street, Sydney, is the chairman of the directorate, and Mr. W. H. Vivian, of Norwich Chambers, Hunter-street, the secretary.

"A large block of coal, about 2 tons, was exhibited from the Mount Kembla Colliery, four miles south of Wollongong, being a section of the coal-seam opened out by Mr. Burall, on the Mount Kembla Coal and Oil Company's property, consisting of 2,100 acres of freehold and leasehold land at Mount Kembla, near Wollongong. It is the upper or No. 1 coal-seam, four feet to four feet six inches in thickness of clean coal, free from bands, identical with that worked at the Osborne-Wallsend, and other collieries in the Illawarra district; and is wrought from an adit at a height of about 750 feet above sea-level. A tramway, five miles in length, has been constructed from the mine to Five Island Point, where a jetty has been constructed, and steam colliers, &c., come alongside and take away the coal. The Illawarra railway, now in course of construction, crosses their tramway at about four miles from the adit, and fifty miles from Sydney. 51,794 tons of round and small coal, valued at £31,076, were raised in 1886, and 150 men and boys were employed daily underground, and 40 aboveground.

"A large block of coal was exhibited from the Mount Pleasant Colliery, Wollongong, on 800 acres of freehold and leasehold land, situated at Mount Pleasant, near Wollongong. The seam averages about seven feet six inches of clean coal free of bands, has an average specific gravity of 1·36 and dips west and north-west about 1 in 30. It is the uppermost coal-seam in the Illawarra district, and outcrops about 600 feet above sea-level in the high ranges fronting the Wollongong harbour, where adits, situated two miles from the Illawarra railway, now being constructed, pierce it, and an incline and locomotive tramway of about three miles in length conveys the coal from thence to the Wollongong harbour. They raised 71,913 tons of round and small coal, valued at £28,355, in 1866, and employed 134 men and boys underground, and 59 aboveground daily, when the colliery was at work.

"A section was exhibited of the coal-seam worked at the Osborne-Wallsend Colliery on freehold land belonging to the Osbornes, at Mount Keira, near Wollongong. It averages about seven feet six inches in thickness of clean coal, free of bands, has an average specific gravity of 1·36, and dips west and north-west about 1 in 30. It is the uppermost coal-seam in the Illawarra district and is found outcropping at a height of about 600 feet above sea-level in the high ranges fronting the Wollongong harbour, where adits, situated two miles from the Illawarra railway, now being constructed, are driven into it, and an incline and locomotive tramway of about three miles in length conveys the coal from

the mine to the Wollongong harbour. 77,386 tons of round and small coal, valued at £28,897, were raised at this colliery in 1886, and 170 men and boys were employed underground, and 55 aboveground daily, when the colliery was at work.

"Coal was exhibited from the Katoomba Coal and Shale Company's Mine, from the No. 1 coal-seam, opened out in 1878 by Mr. North on an extensive area of land at Katoomba, in the parish of Jamieson. Adits have been driven into the coal in a gorge, about 800 feet below the Great Western Government Railway, from which the coal is brought by an incline and endless tramway, two miles in length, to the railway, where it is put into Government trucks, at a distance of sixty-six miles from the metropolis and harbour of Port Jackson. The coal is very free from faults, and has a slight easterly dip. 25,00 tons of round and small coal, valued at £6,250, were raised in 1886; and 55 men and boys were employed underground and 21 aboveground daily when the colliery was at work.

"A block of coal was exhibited showing thickness of the portion of seam worked at the Zig-Zag Colliery; being a section of the Great Western Zig-Zag Company's Lithgow Valley coal-seam, opened out in 1883, and now worked on 410 acres of leasehold and by Messrs. Wilson and Saywell, about one mile from the Vale of Clwydd Colliery, and ninety-six miles by rail from Sydney. The coal is similar in quality, dips in the same direction, and is as free from faults as that worked at the other Lithgow Valley collieries before mentioned. Powerful winding and pumping engines and a substantial pit-top have been erected, and they raised 60,000 tons of round and small coal, valued at £15,000, in 1886; and employed 65 men and boys underground, and 10 aboveground, daily, when the colliery was at work.

"A block of coal was also exhibited from the Lithgow Valley Colliery.—situated about ninety-six miles by rail from the harbour of Port Jackson. This property consists of 1,752 acres, and the coal has been proved on all sides by adjoining workings. The seam is 10 feet 6 inches in thickness, about five feet six inches of which is worked through an adit in a mountain on the western boundary, about 400 yards from the Great Western Railway, with which it is connected by a private siding. The coal lies very regular, is very free from faults, and has a wavy dip of about 1 in 20 east and north-east.

Coal was also shown from the Pulpit Hill and Medlow Colliery.

From the Mittagong Coal-mining Company's Colliery, at Joadja Creek, near Mittagong, a full section of the seam worked was exhibited.

A magnificent display was made of petroleum oil cannel coal, "kerosene shale," and its products, from the Australian Kerosene and Mineral Company's mine and works at Joadja Creek, near Mittagong.

The following is an analysis of the "Shale."

Volatile hydrocarbons	82·50
Fixed carbon	11·00
Ash	6·50
Specific gravity, 1·238.	100·00

"The petroleum oil cannel coal (Boghead mineral) is worked by the above company at Joadja Creek, near Berrima, in the county of Camden, from which place a tramway eight miles in length conveys the mineral to the Great Southern Railway, a distance of seventy-seven miles from Sydney and the harbour of Port Jackson. The dip is about $3\frac{1}{2}°$ north 20° west. A heading has been driven in near the centre of the deposit, and shoots erected for sending down the cannel from the mouth of the heading to a tramway constructed in the valley below. The petroleum oil cannel coal is of excellent quality, lies very flat, is easily and cheaply wrought, and sections of the seam have been laid bare in several places. This Company raised and used in the manufacture of oil and its products, and sold for gas purposes in the colonies, America, and Great Britain, 25,700 tons, valued at £64,250 in 1886, and employed ninety men and boys underground and twenty above ground, daily, when the mine was at work. The richest of the mineral gives 15,399 cubic feet of 48-candle gas per ton, and has a specific gravity of 1·098. When made into oil and its products, it yields over 150 gallons of crude oil to the ton. The products obtained from the company's 'shale,' consisted of kerosene oil, soaps (various kinds), candles (various kinds), lubricating oils, lubricating greases, stearine, paraffin, sulphuric acid, wood preserving oil, brick oils, liquid fuel.

"A full section was exhibited from the petroleum oil cannel coal-seam worked by the New South Wales Shale and Oil Company at Hartley, near Mount Victoria, in the county of Cook. An incline and tramway about one mile in length takes it to the Great Western Railway, at a distance of eighty-one miles from Sydney and the Port Jackson harbour. It dips to the east. This is the mine where oil and its products were first manufactured from the New South Wales boghead mineral in 1865, our late Attorney-General—Mr. J. Want—being then the manager of the mine and oil works erected adjacent thereto, which works were afterwards removed to Waterloo, Sydney, where the manufacture of oils, paraffin, and other products are still carried on successfully. They raised and used in the manufacture of oil and its products, and sold for gas purposes in the colonies, America, and Great Britain, 17,863 tons, valued at £35,726, in 1886; and employed 100 men and boys underground and above ground daily, when the mine was at work. The richest of the mineral yields over 130 gallons of crude oil per ton when used for oil and its products, and over 18,000 cubic feet of 40-candle gas when gas only is extracted from it. Its specific gravity is 1·052.

Petroleum oil cannel coal was exhibited from Ruined Castle, Katoomba, yielding in 100 parts—

Sp. Gr. 1·046.

Hygroscopic moisture	·35
Volatile hydrocarbons	81·02
Fixed carbon	10·10
Ash	5·00
Sulphur	·53
	100·00

From Bathgate, Marangaroo, one hundred and one miles by rail from Sydney, yielding about 17,000 cubic feet of gas per ton, with an illuminating power of over thirty-six candles, or ninety gallons of crude oil per ton.

And also from Sugarloaf, Mount Victoria, seventy-seven miles by rail from Sydney, yielding over 17,000 cubic feet of gas per ton, with an illuminating power of about thirty-eight candles, or ninety to one hundred gallons of crude oil per ton.

Graphite was exhibited from Undercliff Station, near Wilson's Downfall, New England, but was of poor quality.

IX.—Note on two specimens of *Lepidodendron* from the Lower Carboniferous (?) of Goonoo Goonoo; by ROBERT KIDSTON, F.G.S., of Stirling, N.B.

[Plate V.]

IN both specimens, all traces of the original plant have entirely disappeard, and we have only their impressions on a very soft ochre-coloured matrix, which shows well the present form of the leaf-scars. Both the fossils have been much distorted by pressure, active in a direction almost parallel to their growing axis; or, in other words, to speak of the leaf-scars individually, active on their upper margins. That the leaf-scars do not now possess their original form, is at once evident from their irregular and contorted outlines.

As proof of the correctness of this conclusion, if we examine the smaller and more sharply defined specimen (Pl. V, fig. 1) which is only about 2½ inches long, and an inch wide, it is seen that the leaf-scars at its uper part, are more compressed than those towards its base; and in the other specimen, of which two leaf-scars slightly enlarged, are shown in Fig. 2*a*–*b*, they are even less compressed than those at the lower part of Fig. 1.

The general appearance of the specimens, though difficult to express in words, will be admitted by all, who have had any practical experience of fossils, to be the result of pressure acting in the direction already indicated.

Concluding that the fossils do not now show the original form of the leaf-scars, the next question demanding consideration is whether any known species of *Lepidodendron*, if subjected to similar conditions, would be likely to assume the form of the Goonoo Goonoo examples. When dealing with *Lepidodendra*, in almost all cases, unless we have well preserved leaf-scars, their specific determination is

very unsatisfactory. The present fossils have fortunately certain characters of so well marked a type, that though perhaps not enabling us to determine the species with positive certainty they agree so closely with *Lepidodendron Volkmannianum*, Sternb., that their identity with this plant appears to me very probable. Two leaf-scars of *L. Volkmannianum* are shown (Pl. V, Fig. 3), for the purpose of comparison with the Australian specimens. It will be seen in comparing these figures that the leaf-scar of *L. Volkmannianum* has a flat basal boundary line (Pl. V, Fig. 3*b*), with a rounded upper margin (Pl. V, Fig. 3*a*). Now, if we compare Figs. 2*a* and 2*b*., scars from the larger Australian example, with the sketch of *L Volkmannianum*, it will be seen that the form of the parts, bearing the corresponding letters, agree pretty well, allowance being made for the pressure to which the specimens have been subjected. Of all *Lepidodendra*, *L. Volkmannianum* is perhaps the only one which has characters so peculiar to itself, that would allow of any comparison with distorted specimens, such as those under consideration, and the little evidence the present fossils afford, points to their identity with that species.

In Mr. C. S. Wilkinson's letter, accompanying the fossils, which were collected by Mr. D. A. Porter, of Tamworth, he gives as their horizon "Lower Carboniferous or Upper Devonian (?)" *L. Volkmannianum* is, I believe, as far as at present known, restricted to the Culm of the Germans, and its equivaleut in Great Britain, the Calciferous Sandstone Series of Scotland. From an isolated species, and that not being quite free from doubt, as to its specific identity, we are not in a position to corelate horizons, but taking into consideration all the circumstances of the case, I am more inclined to regard the beds from which it was collected as Lower Carboniferous than Upper Devonian.

It is very desirable that additional and better preserved specimens be secured, from which these notes might be confirmed or rejected.

The following references to the literature of *Lepidodendron Volkmannianum*, Sternb., may be of assistance to those who may wish to examine the matter for themselves:—

Lepidodendron Volkmannianum,	Sternberg, Vers., I. fasc. 4, p. X, pl. LIII, f. 3.
„	Schimper, Traité Pal. Vég., vol. II, p. 23.
„	Stur, Culm Flora, Heft. II, p. 393, pl. XVIII, f. 4, and pl. XXIII, 2–4 (5?).
„	Renault, Cours. Bot. Foss., 1882, Ann. II, p. 17, pl. I., f. 8.
Sagenaria Volkmannianum,	Sternberg, Vers. II, p. 179, pl. LXVIII, f. 8.
„	Römer, Palaeontographica, vol. III, p. 46, pl. VII, f. 15.
„	Rhode, Beiträge zur Pflanzen Vorw., 1820, p. 32, pl. VII, f. 4 and 5.

X.—On the Post-Tertiary Ossiferous Clays, near Myall Creek, Bingera; by WILLIAM ANDERSON, Geological Surveyor.

[Plates VI—X.]

I.—*Introduction.*

DURING the past fifty years numerous discoveries of the fossil bones of extinct Post-Tertiary vertebrates have been made from time to time in various parts of this Colony, and in other parts of Australia. Among the earliest notices of their occurrence in New South Wales are papers by the following authors:—W. Pentland (1830)*, Professor Jamieson (1831)†, and Major Sir T. L. Mitchell (1831)‡. Since that time the literature dealing with the description of the various gigantic animals whose bones have been periodically unearthed, and the deposits in which they lay, presents quite a formidable list of papers, the majority of which are from the pen of Prof. Sir Richard Owen.

The deposits in which Post-Tertiary fossil bones have been found in Australia may be classed in two groups—the Pleistocene and Recent alluvia, clays and river drifts; and the Post-Tertiary ossiferous breccias of our limestone caves. The former group comprises a variety of deposits. Isolated bones and small collections of bones have been frequently met with in the soils and subsoils, where these have been laid bare in section by superficial denudation, chiefly on the great interior plains of this Colony and Queensland, but also over the Colony generally. They likewise occur in clays which represent old dried up boggy springs or lagoons, such as the "Cuddie Springs" on Mara Creek, near Brewarrina, and in distinctly stratified deposits sometimes of considerable extent, which have evidently been laid down by running water, such as the Myall Creek deposit near Bingera; while in some instances, as at Young and Gulgong, they occur in Pleistocene river drifts.

The more important deposits, however, are those of the second group, comprising the ossiferous breccias in our limestone caves, such as the Wellington and Fish River Caves, &c. The majority of the bones occurring in these breccias have no doubt been introduced into the caves by the action of streams, the evidences of which, in the presence of well rounded pebbles, are well marked in almost every case. In this Colony the limestone beds in which our principal caves have been worn, many of them containing bone breccias, are coralline, generally of a dirty

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* Communication verbale sur les Ossements trouvés dans une Brêche calcaire sur la Rivière de Hunter (N. S. Wales). *Bull. Soc. Géol. de France, 1830, I, p. 144.*

† On the fossil bones found in the Bone Caves and Bone Breccias of New Holland.—*Edinburgh New Phil. Journ., 1831, X, p. 393.*

‡ An account of the Limestone Caves of Wellington Valley, N. S. Wales.—*Proc. Geol. Soc., 1831, I, No. 21, p. 321; and Edinburgh New Phil. Journ., 1831, XXV., p. 179.*

bluish grey colour, and belong to the Siluro-Devonian series. Although in the breccias the fossil bones are in a better state of preservation than they are in the Pleistocene clays, &c., the latter ossiferous deposits are still of great importance, and will amply repay systematic exploration.

The fossil vertebrate remains thus preserved to us are of the most interesting character, revealing, as they do, the gigantic marsupial fauna which must have existed on this continent during a comparatively recent period, and exhibiting an analogous feature in animal development to that which has been found to have obtained in other continents, where, during Pleistocene times, there existed in each great endemic area, a fauna consisting of giant representatives of that of the present time in the same area. It is still an open question, from the few systematic explorations of our bone deposits that have been made, whether representatives of any of the species of our larger Pleistocene vertebrates were in existence after the appearance of man on this continent. In New Zealand we have conclusive proof that a gigantic representative of its Pleistocene fauna in the Moa (*Dinornis*), existed down to the human period, and, for a considerable time after the advent of man, co-existed with him. In this relation, there are other deposits besides those which have been laid down by natural agencies, to which careful attention ought to be given, namely, the more or less artificial accumulations left by man, analogous to the "kitchen-middens" and other deposits of Northern Europe, which contain human remains and relics, and the bones of the animals on which he subsisted. Doubtless, there are numbers of such accumulations in various parts of the Colony, but particularly along the sea coast, in positions which were habitually frequented by the various tribes, or smaller communities, either as camping grounds or rock-shelters during certain periods of the year, or as places set apart for the performance of certain rites and ceremonies. At the present time we have far greater facilities for obtaining a knowledge of the position of such localities than will be the case with future investigators, because we have still among us numerous persons who during the early days of the Colony were personally acquainted not only with the manners and customs of the native blacks, but also with the exact localities which were most favoured by the latter as positions for camping, or for the performance of their various ceremonies. It is probable that many of these places were frequented by generation after generation of the same community. If such were the case, we may expect to find, on investigation, not only human weapons, and probably human remains, in such localities, but also the bones of the animals which co-existed with man, and whose flesh he used for food. It will thus be seen that if, by such investigations, we are to prove or disprove the co-existence of representatives of these gigantic Pleistocene vertebrates with man, our explorations must also be carried on among those deposits in which his remains are likely to be found; so that investigations in Post-Tertiary palæontology and pre-historic archæology must be carried on simultaneously.

II.—Localities.

The chief localities from which Post-Tertiary vertebrate remains have been obtained in New South Wales, are the following:—

Post-Tertiary alluvia, clays, &c.—Cuddie Springs, near Brewarrina; Myall Creek, near Bingera; Liverpool Plains; Tamworth; Paroo River; Barrier Ranges; Hunter River; Pye's Creek, near Vegetable Creek; Armidale; Gulgong; Young; &c., &c.

Caves (bone breccias).—Wellington; Fish River; Wombeyan; Murrumbidgee (Cave Flat); Goodridigbee; Cowra, or Belubula; Isis River; Molong; Boree.

There are numerous other known caves, which have, however, never yet been explored for fossil bones, but in which they would doubtless be found if systematically investigated. Among these the following may be mentioned:— Yarrangobilly, Kempsey, Abercrombie, Wollombi, Cargo, &c.

Besides the remains of the larger extinct Pleistocene vertebrates, there are to be found in almost all our caves, chiefly in the accumulated dust which covers the floors of the smaller side chambers, the bones of recent existing marsupials, such as wombats (*Phascolomys*), wallabies (*Halmaturus*), bats, rats, and mice, &c.

At the Canadian Gold-lead, near Home Rule, about half-way between Mudgee and Gulgong, the auriferous Tertiary river drift was found to occupy a large irregular cavity in limestone, which in Tertiary times must have been a cave opening into the valley in which the river drift was being deposited. In the wash-dirt in this cave a number of fossil bones were discovered, but they are, however, the remains of truly Tertiary animals.

III.—Myall Creek Deposit.—Position.

The bone deposit which has just been worked out, is situated at Bone Camp Gully, on Portion 121, Parish of Durham, County of Murchison (Pl. VIII). Sections of the series of beds among which it occurs, were exposed by being cut through by a small creek, running northwards into Ironbark Creek, which is an affluent of Myall Creek, a tributary of the Gwydir River. The deposit is about six miles south-east from Mr. M'Donald's station, on Myall Creek, which is sixteen miles to the east of Bingera, on the Bingera and Inverell road.

IV.—Geology of District.

In this district the country presents an irregularly undulating appearance. In geological structure in consists chiefly of Tertiary basalt, with here and there an occasional outcrop of the underlying Palæozoic rocks, of limited extent, in some places exposed by the denudation of the basalt which had covered them, and in others the slate hills still stand high above the level of the basalt, as they no doubt

did during the time when the Tertiary lavas overflowed and flooded so large an area of the north-eastern part of this Colony. Superficially most of the country, especially the flats, along the courses of the creeks, and the low-lying grounds, is covered by a considerable thickness of black soil, which when moist is a tenacious and unctuous clay, and has been chiefly derived from the decomposision of the Tertiary basalt. In numerous positions where the basalt has been either pierced in well-sinking, or worn through by surface denudation, the characteristic Tertiary valley deposits are found to be present under large areas. These consist of variously-coloured pipeclays, with beds of more or less carbonaceous clays and gravels. Of Pleistocene and recent deposits there are the series of clay beds among which the bones occur, the black soil alluvia, which have a very general distribution, and the pebbly drifts and sands of the present water-courses. In the immediate vicinity of Bone Camp Gully, the principal geological feature is the prevalence of Tertiary basalt, with the Pleistocene clays, which cover the greater part of the 40-acre block, No. 121, besides portions of the neighbouring blocks. A short distance to the south of the gully there is an old river course, represented by a considerable thickness of pebbly drift. About ten chains up, on the western side of the gully, is a small cliff, formed of a series of slightly calcareous grits, sandstones, and shales, which dip at a low angle towards the south. Here the ossiferous clays are seen to rest unconformably on the upturned edges of these rocks, which may probably form a small outlier of the coal-bearing Carboniferous strata which cover such a large tract of country some distance to the west. About six chains up the gully from the junction of the two creeks a spring rises in the bed of the creek from below the lowest clay bed. The flow of water from it is periodical, and seldom lasts for any length of time. Sometimes the creek bed below it is completely dry one evening, and next morning the water is seen flowing along it quite freely. The spring occurs opposite that portion of the western bank of the creek at which the bone bed outcrops.

V.—Description of Sections.

The sections of the various Pleistocene clays exposed in Bone Camp Gully differ from each other on the two sides of the gully. The eastern side is formed entirely of light grey and white clays, covered with surface soil, these grading gradually into each other without showing any distinct line of demarcation. No bones were found in the clays on this side of the creek. On the western side the whole series of beds is exposed. Their total thickness probably does not exceed thirty-five feet, the bone bed occurring about midway in the series. This section (Pl. X.) consists of the following beds, as seen in the face laid bare during the excavations:—(1) Greyish black soil and subsoil passing downwards into—(2) a greenish grey clay. which, at a depth of six feet nine inches from the surface, rests upon—(3) a bed of black carbonaceous clay, four feet nine inches in thickness, which becomes gradually a light chocolate colour towards its upper and lower surfaces. Immediately below

this is—(4) the bone bed proper, which varies in thickness from one to three feet, and is a stiff, tenacious, greenish-grey clay, which passes downwards for a considerable depth, carrying isolated bones, and containing less clay, with more sand and pebbles towards it lower surface. This bed, with its upper ossiferous portion, must be at least eight feet thick. Some three chains up the gully it is seen to rest on the decomposed upper surface of the Tertiary basalt, while higher up it rests on—(5) a bed of ferruginous pebbly grit, on which the present creek is now depositing its flood sands. The beds have all a slight dip towards the north-west. The black carbonaceous clay bed thins out before reaching the eastern side of the gully, and the bone bed proper is not present on that side of the creek. The outcrop of the bone bed with the overlying carbonaceous clay extends in a north and south direction along the western side of the gully for a distance of about five chains, and they both thin out in those directions. The upper surfaces of the various beds, where distinctly seen in section, present a wavy outline.

VI.—Description of the Bone Bed proper.

A few isolated bones occurred for some distance down in the lower clay bed, and also scattered through the black carbonaceous clay, but the chief deposit was in the upper part of the former. Vertically the portion carrying the bones varied in thickness from one to three feet, while horizontally, along the outcrop of the beds, it extended north and south for a distance of one and a quarter chains. It was proved, by the excavation made, to extend from the outcrop, in a westerly direction, for about one and a quarter chains, and at that distance the bones had not altogether disappeared. Laterally along the outcrop isolated bones occurred outside the area, where they were most abundant. The lower portion of the bed is a somewhat loose sand, containing pebbles, but towards the top, where the chief collection of bones occurred, it was principally clay, with fine grains of quartz and occasional pebbles. The pebbles occurring in the clay along with the bones were not very numerous, except in a few spots, and consisted of the following rocks:—altered Silurian slates, jasperoid rock, quartzite, quartz, Tertiary basalt and tachylite, calcareous grits and shales. The first four varieties were the most common. All the pebbles were of small size, well-rounded, and water-worn, the largest not exceeding three inches in diameter. The least rounded and largest fragments were the pebbles of calcareous grit and shale, which were identical with the series of inclined calcareous rocks which are exposed close by in the bed of the creek, and on which the clay beds rest uncomformably. The pebbles were less frequent in their occurrence from below upwards in the bed at the top of which the bones lay, and passing upwards they gradually disappeared, until, in the black carbonaceous clay overlying the bone bed, they occur but rarely. The clay in which the bones are embedded is stiff and tenacious when moist, but loses all its viscosity and falls

into dust when exposed to the air, or heat of the sun. This enables the bones to be easily and thoroughly cleaned, because, when dry, the adherent clay can readily be picked or brushed off.

VII.—Mode of Occurrence of the Bones.

Although the bones had a wide distribution, both vertically and horizontally, throughout the clay beds, there was only one position in which they were obtained in any abundance, and in a fair state of preservation, namely, at the top of the lower greenish-grey clay. Here they lay in a jumbled mass, sometimes in small pockets, where they came in contact with each other; but generally they occurred singly, often a few inches, and sometimes a few feet apart. The long bones and larger flat bones were never found standing vertically in the clay, but were always in a horizontal position, or only slightly inclined when one end of a bone rested on its neighbour. The smallest depressions and foramina in the bones were filled with clay, which at the time of deposition must have been of the consistency of fine mud. Pebbles occurred not unfrequently in the clay with the bones, as if brought into position along with them. When first exposed the latter were so saturated with moisture that they readily went to pieces, unless handled very carefully; but many of them, when allowed to dry thoroughly, became quite hard and sound. As a rule, however, they were very soft and friable, and great difficulty was experienced in getting the larger bones out whole. In many cases large masses of the clay in which a bone was embedded had to be removed along with it, and the bone only separated from the clay after it had been dried and strengthened. The isolated bones occurring in the black carbonaceous clay were so much decomposed that they would not bear removal; in fact, the position of the majority of them was only marked by a ferruginous stain, the bony substance having entirely disappeared.

VIII.—Principal Bones occurring.

The excavation made in order to remove the bones, which had to be picked out individually, was of considerable extent. Several tons of bones were recovered, but the majority of them were more or less broken, although many perfect specimens were procured. Those which occurred most frequently in the deposit were the long bones of the limbs, the small bones of their distal extremities, and vertebræ, and, as a rule, these were also the most perfect, and in the best state of preservation. Rib bones were rather common, but were mostly broken into short fragments. Of the vertebræ, specimens of the axis and atlas were usually found entire, both in the case of those which had belonged to the smaller animals, such as the kangaroo (*Macropus*), &c., and also to the larger forms, such as *Diprotodon*, &c. Generally, however, only the bodies of the other vertebræ remained, the spines and the various processes having been broken off. Jaws, both large and

small, occurred frequently, while isolated teeth were very abundant. The lower jaws of the larger forms were more frequently met with than the upper; indeed, the latter were rather rare. When they did occur, however, they never formed part of an entire cranium, but always consisted of the upper maxillary and palatal bones only, the rest of the cranium being absent. So far as I saw, there was no specimen that could be demonstrated to be a portion of the cranium proper of one of the larger animals, although there are undoubtedly small fragments of the cranial bones among the collection, which has, however, not yet been thoroughly examined. The bones of the pelvis were of rare occurrence, fragments of the thickest part of the os innominatum, about the rim of the acetabulum being the part generally met with. In one instance, however, a very large portion of the pelvis of one of the larger animals was found, consisting of the greater part of one os innominatum, and the sacrum. Nearly perfect specimens of large scapulæ were in a few cases obtained, while fragments of the scapulæ of smaller animals, generally consisting of the articular head of the bone, with a portion of the neck and the coracoid process, the blade being wanting, were of frequent occurrence. The remains of birds, although by no means common, were often met with.

Occurring in the ossiferous portions of the clays were numerous small fragments of bones, generally a few inches in length, and chiefly pieces of the longer limb bones, which had been broken into fragments prior to their deposition in the clays. In almost every case the sharp fractured edges and angles of these fragments had been slightly rounded by attrition, but they were by no means so well water-worn as the pebbles which occurred along with them. The fragments of the thicker bones rarely showed an entire transverse section of the bone, which had not only been fractured transversely, but also longitudinally. In the case of fragments of the thinner bones, the transverse section is generally complete, the bone not having been fractured longitudinally. The large majority of the broken fragments show unmistakably the teeth-marks of some carnivorous animal, or animals. Most of these marks are, however, too fine to have been produced by the carnassial teeth of *Thylacoleo*, although there are some of them which seem large enough and coarse enough to have been so produced. The fragments of bones which show evidences of having been gnawed, are chiefly pieces of the shafts of the longer limb-bones and ribs. The teeth-marks occur singly along the surface of the fragments, corresponding marks being often present on the opposite surface, indicating the action of the teeth of both jaws on the bones. Generally, however, the marks are confined to one or both ends of the fragments, which often bear evidences of having been bitten sharp off, while close to the sharply bitten end the surface is furrowed with teeth-marks, showing that whatever the animal was, by the action of whose teeth the marks were produced, it had a similar habit to that which the dog, and other carnivora possess, of holding one end of the bone on the ground,

between the fore-paws, while it gnawed the opposite free end. Few of the teeth-marked fragments of bones belong to the skeletons of the larger animals whose remains occur in the deposit.

IX.—General Conclusions.

Age.—There can be little doubt as to the comparative age of this ossiferous deposit. From the presence of pebbles of Tertiary basalt and tachylite, and the fact that the whole series rests upon the Tertiary basalt of the district, its origin is certainly of Post-Tertiary date. The thickness of the series, the occurrence in the deposit of angular, as well as rounded water-worn pebbles, together with the relation which the whole series bears to the general level of the county, all point to the supposition that it more probably belongs to the Pleistocene than to the Recent period.

Origin.—The facts bearing on its probable origin, however, are hardly so clear and conclusive as those relative to its age. So far as observation went, no two or more bones, which might have been articulated together in the living animal, were found lying in such a relation to one another as to favour the supposition that they had been still united by ligaments or muscles at the time that they were deposited in these clays. This fact, taken in conjunction with many of those stated below, negative the idea that the animals whose bones occur here, died through getting bogged in this position, which at that time might be supposed to have been a boggy swamp. It does not seem likely that the periodically active spring coming from below the series of clays, had anything to do with their formation. It is, probably, merely an outlet for the drainage of the area covered by the series of clay beds. From the distinctly stratified character of the deposit, and the facts that the long bones and flat bones, almost without exception, were found to lie with their longer axis horizontally, that most of the broken fragments of bones had their fractured edges and angles slightly water-worn, and that all the weaker and more easily destroyed portions of the bones were absent, it may safely be concluded that the deposits were formed and the bones brought into position by the agency of running water. The current could not have been very rapid, for the pebbles are never large, and judging from the uniformity of texture of the various beds, its velocity must have remained very uniform during the whole period of deposition, although the occurrence of the pebbles less frequently from the lower beds upwards in the series, shows that during the deposition of the upper beds its power must have become somewhat diminished. The presence of pebbles of calcareous grit, &c., similar to the rocks that are seen *in situ*, farther up the gully, would indicate that the direction from which the current came was from the southward, the present drainage of the district being also from that direction. The transportation of the bones must have extended over a considerable period of time, during the deposition of the successive beds. They were first carried in

singly, while the lower clays were being laid down, their number gradually increasing until a maximum was reached in the bone bed proper, and thereafter only isolated specimens were deposited along with the overlying carbonaceous clay. The two latter beds seem to form merely a local patch in the whole series of clays, occupying a circumscribed area and intercalated as a lenticular mass among them, the upper and lower grey beds of which, in the section in Bone Camp Gully, are very similar in character and occur outside the area of the carbonaceous clay as a single bed of considerable thickness. During the deposition of these ossiferous clays, the general physical features of the surrounding country must have been very much what they are at the present time, except for the effects of superficial denudation in lowering the high grounds, and tending to produce a general levelling of the country. The fact that many of the bones show distinct evidences of having been gnawed would, I think, indicate that they had lain exposed on the surface of the ground for a considerable time before they were washed into the present deposit where they were immediately covered up. That they have been transported as individual bones from some neighbouring locality into the deposit in which they were found, seems to me beyond a doubt, and it is probable that the transporting agent is to be found in the stream which laid down the gravels, and of whose former presence we have evidence in the immediate neighbourhood to the south, the direction from which the transporting current probably came.

We frequently see at the present time, on many of our rivers, the formation of stratified sand and clay deposits of considerable extent, and quite similar to those under consideration, although, no doubt, they are being formed more slowly than was the case in Pleistocene times. Such deposits are generally formed at intervals along the courses of rivers where the enclosing high grounds widen out and leave more or less open flats, whose general level in the neighbourhood of the river's banks is nearly the same as that of the river itself, and the outlet from which is somewhat confined. These flats, during every periodical rise in the waters of the river or creek, become flooded, and on them are accumulated the sandy clays and finer sediments, which are carried over a wider area, where the currents are slower, than the heavier material (gravel, boulders, &c.) which is deposited in the immediate neighbourhood of the channel proper, where the current is much more rapid, and consequently its transporting power much greater. It seems to me probable that, under conditions such as these, the bones were transported from some neighbouring locality in which they had been accumulated, and were redeposited in their present position. It is clear that they could not have been transported any great distance, but, under what conditions they occurred in the position in which they were originally accumulated we have at present, no evidence to show. Whether they were washed from a prior deposit, or cleaned out from a cave or rock-hollow, or whether they had been primarily deposited in a boggy swamp

which in course of time may have been washed away by the river, so far, there are no facts to prove; but there is not the slightest doubt that the position from which they were exhumed, was not the original one in which the skeletons of the various animals, whose remains occur in the deposit, were disarticulated into their separate bones.

The question may present itself as to whether or not such Pleistocene ossiferous deposits were of glacial origin, that is to say, were they deposited as a result of the presence of glacial conditions of climate in the more elevated parts of the Colony, with a consequent lowering of temperature generally? And was such a lowering of temperature one of the causes of the extinction of these large Pleistocene vertebrates? Taking the deposits themselves, there is nothing to indicate that the clays were a product of ice-erosion, nor do the pebbles show any traces of glacial action. As the remains of these animals have been found high up in the New England District, in the northern part of the Colony, that portion, which, under glacial conditions, would be the most intensely glaciated, their distribution in early Pleistocene times must have been very general. So little attention has yet been paid to glacial phenomena in this Colony, and so few facts relating thereto collected, that from the present state of our knowledge a Post-Tertiary Glacial Epoch cannot be demonstrated to have been an indisputed fact. There are, however, unmistakable evidences in South Australia, and probably Victoria, that a cold period intervened between the middle Tertiary and the present time. If such glacial conditions obtained in this Colony during later Pleistocene times, there can be little doubt that they were among the most potent causes of the extinction of these large Pleistocene vertebrates, just as has been proved to have been the case in other parts of the world where the large Pleistocene forms of life died off on the advent of glacial conditions of climate. But neither the deposits themselves nor the surrounding country show evidences of glacial action, so that the facts obtained from a study of these Pleistocene bone deposits in this relation do not warrant, nor even tend towards the conclusion that the extinction of these animals was due to the approach of a period of diminished temperature immediately anterior to the present time.

Among that portion of the collection which I had the opportunity of cursorily examining in camp, there were no evidence of man, either in the presence of his implements or weapons, nor in the occurrence of his remains. It is of the greatest importance that we should have the evidence for or against the contemporaneity of man with those Pleistocene animals, based upon observations made during the excavation of such deposits as the present, but so little systematic work of this kind has yet been done that the facts recorded relating to this interesting question are of the most fragmentary and unsatisfactory kind. By working out both sets of deposits, on the one hand by the excavation of the Pleistocene ossiferous

deposits, and on the other by the exploration of the recent accumulations left by man, we should be certain to discover a point which would give us the earliest evidences of his presence, but as yet we cannot say whether that point was before or subsequent to the total extinction of the gigantic Pleistocene fauna, and it can only be conclusively proved by the laborious, careful, and systematic exploration of all our Post-Tertiary accumulations both natural and semi-artificial.

The palæontological significance of such collections of Pleistocene bones as this cannot fail to be of the utmost importance and scientific interest, as helping to elucidate the questions relating to the evolution of the almost unique indigenous vertebrate fauna of the present time in this island-continent.

I must acknowledge here the great interest taken and the ready assistance given by Mr. McDonald, of Myall Creek Station.

The collection was made after much trouble and labour by the Survey Collector, Mr. C. Cullen.

XI.—On Further Evidence of a Large Extinct Struthious Bird (*Dromornis*, Owen), from the Post-Tertiary Deposits of Queensland; by R. Etheridge, Junr., Palæontologist.

[Plates XI—XIII.]

I.—Introduction.

A small collection of bones, found at an old spring in sinking a well, at a depth of twenty feet from the surface at Thorbindah, near Cainwarra Station, on the Paroo River, were recently forwarded to the Government Geologist, by Mr. A. S. Cotter, of that place. In addition to bone fragments of kangaroos and *Diprotodon* and teeth of the latter, three specimens especially attracted notice as the remains of birds. A closer inspection showed them to be the right tibia and left fibula of a large Struthious Bird, and the right tibia of an Emu (*Dromaius*).

II.—History of Struthious Birds.

Before describing these in detail, it may not be without interest to refer to the history of Struthious Birds in Australia. The first intimation of the former existence of this interesting group on this continent seems to have occurred to Professor Sir Richard Owen amongst the gatherings of the late Sir Thomas Mitchell, Surveyor-General of New South Wales, from the Wellington Caves. In the Palæontological Appendix to Mitchell's "Three Expeditions into the Interior

of Eastern Australia,"* Professor Owen figured† a femur, which he referred to in subsequent writings‡ as that of a "large struthious bird." From 1838 until 1869 nothing appears to have transpired relating to extinct birds in Australia, but in that year the late Rev. W. B. Clarke wrote to the Editor of the *Sydney Morning Herald* (letter dated May 19th), announcing the discovery of a *Dinornis* femur from under thirty feet of alluvial clay covering 150 feet of drift, in a well on the Peak Downs, between Lord's Table Mountain and the head of Theresa Creek. The day previous to this, however (May 18th, 1869), the late Mr. Gerard Krefft, then Curator of the Australian Museum, wrote to the same paper, stating that the specimen in question was the "shank bone" of a bird "allied to the flightless moas." This opinion was reiterated in the year but one after,§ when he compared this interesting relic to the similar bone of the extinct *Dinornis robustus*, Owen, of New Zealand.

Mr. Clarke's letter was republished in the *Geological Magazine*|| in 1869, but a curious discrepancy exists between these two documents. As communicated to the *Herald*, the letter states that the femur was found under the alluvial clay, "covering 150 feet of drift, and rested on what is said to have been a granite rock." In his letter to the *Geological Magazine*, on the other hand, Mr. Clarke says that the alluviul matter "rested on 150 feet of drift, pebbles, and boulders, on one of which (at that depth) rested a short thick femur." From these contradictory statements the position of the bone in question must remain a doubtful point. A plaster reproduction was sent by the Rev. Mr. Clarke to Sir Richard Owen at the same time, the original remaining in the Australian Museum. On receipt of the cast, this eminent osteologist was able to demonstrate the relation of the bone to the corresponding one, not in the Moa (*Dinornis*), but in the existing Emu, and named in *Dromornis australis*.¶ The full description was published later,** and from this excellent memoir the following quotation may be taken:—"I infer that in its essential characters this femur resembles more that bone in the emu than in the moa, and that the characters in which it more resembles *Dinornis* are concomitant with, and related to, the more general strength and robustness of the bone—from which we may infer that the species manifested dinornithic strength and proportion of the hind limbs, combined with characters of closer affinity to the existing smaller, more slender-limbed, and swift, wingless bird peculiar to the Australian continent."

It should have been noted that, following Mr. Krefft's determination of this bone as that of a *Dinornis*, Mr. Clarke was led to indulge in some speculations on

* Two vols., 8vo. London, 1838.
† Pl. 3, figs. 12 and 13.
‡ Trans. Zool. Soc., 1873, viii., Pt. 6, p. 381.
§ Australian Vertebrata, recent and fossil, p. 37. (8vo., Sydney, 1871. Government Printer).
|| Geol. Mag., 1869, vi, p. 383.
¶ Proc. Zool. Soc. 1872, p. 682.
** On *Dinornis* (Part XIX): Containing a description of a femur indicative of a new genus of wingless birds (*Dromornis Australis*, Owen), from a Post Tertiary deposit in Queensland.—*Trans. Zool. Soc.*, 1873, VIII., Part 6., p. 381, t. 62 and 63,

the former probable union of Australia and New Zealand. In consequence, however of Professor Owen's researches, such views were abandoned by the Father of Australian Geology.*

The next discovery of bird remains in Australia, or, perhaps, it should be said the preservation, is again due to the Rev. W. B. Clarke, who, in January, 1876, received from a Mr. Deitz the pelvis of a large bird, found at a depth of 200 feet at the Canadian Gold Lead, near Mudgee, County of Phillip,† From photographs of this fossil, Professor Owen wrote as follows:—"I make out the left acetabulum and surrounding parts of the pelvis of a bird about the size of *Dinornis ingens*, but differing in certain proportions of parts."

This pelvis is referred to in Sir Richard's twenty-first "Memoir on *Dinornis*,"‡ wherein, speaking of the above photographs, he remarks that the specimen "formed part of a bird's pelvis as large as that of the *Dinornis elephantopus*." In this essay there is also described "the left tibia of a flightless bird," and corresponding in size with the same part in *Dinornis elephantopus*. The bone in question is described in detail, and is believed to have been found in the Mount Gambier Range, South Australia. The interest attached to the fossil found by Mr. Cottor will be at once manifest, bearing in mind that it is a portion of the right tibia of such a bird.

This examination of the Mount Gambier fossil enabled Professor Owen to "establish the fact of a nearer resemblance in the tibia, as in the femur, of the gigantic wingless bird of Australia, to the genera still there represented (*Dromaius*, *Casuarius*), than to *Dinornis*, *Apteryx*, or *Struthio*."

Only two other references are necessary in this brief history of Australian struthious birds, namely to Sir Richard Owen's work on the "Extinct Wingless Birds of New Zealand,"§ in which his previous descriptions are recapitulated; and a more recent paper by Mr. C. W. de Vis, "The Moa (*Dinornis*) in Australia."‖ In this interesting communication the author describes a portion of the proximal end of the left femur of a struthious bird from the Darling Downs deposits. Although he produces several interesting facts in support of the dinornithic affinity of this bone, it opens up questions of such magnitude that further confirmatory evidence is desirable before the occurrence of *Dinornis* in Australia is accepted as a fact. Mr. de Vis has obligingly supplied the Mining and Geological Museum with a cast of this fragment, and I must confess that the resemblance between it

* See Sedimentary Formations of N. S. Wales, 1875, 3rd edit., p. 5; 1878, 4th edit., p. 101.

† On *Dromornis Australis* (Owen), a new fossil bird of Australia.—*Journ. R. Soc. N. S. Wales for 1877, 1878.* XI, p. 41.

‡ On *Dinornis* (Part XXI): Containing a restoration of the skeleton of *Dinornis maximus*, Owen, with an Appendix, on Additional Evidence of the genus *Dromornis* in Australia.—*Trans. Zool. Soc.*, 1877, X., p. 186.

§ "Memoirs on the Extinct Wingless Birds of New Zealand, with an Appendix on those of England, Australia. New Foundland, Mauritius and Rodriguez" (2 vols., 4to London, 1879).

‖ Proc. R. Soc,, Queensland, 1884, I pt. 1, p. 23, t. 3 and 4.

and the corresponding bone in *Dinornis* is a strong one. To sum up then we find that four separate discoveries of bones of an extinct wingless bird have been made on the Australian continent, as follows: —

Wellington Caves—A femur, by Sir. T. L. Mitchell.
Peak Downs—A femur (Rev. W. B. Clarke).
Canadian Lead—A pelvis, by Mr. Dietz.
Mount Gambier Range—A tibia (Professor Owen).
King's Creek—A femur (Mr. C. W. de Vis).

Now, the femora and the tibia, coming from what may be generally termed quaternary deposits, may, for arguments sake, be considered of the same geological age. But it is questionable if the pelvis from the Canadian Lead can be so regarded. As previously stated, it was found at a depth of two hundred feet in an auriferous lead of supposed Pliocene age, and it is therefore somewhat premature to class these remains as all of one period. Rather, would it not be better to consider the pelvis from the Canadian lead as one of the earliest bird remains yet extant on this continent, and of Pliocene age; and those from the other localities as representing a Post-Pliocene period. The following extract from a letter* of Professor Owen's to the Rev. Mr. Clarke will show that the Professor provisionally regarded the whole of these remains as one species—"The probabilities are that the femur from the breccia-cave of Wellington valley, that described from Peak Downs, your portion of a pelvis, and the South Australian tibia, are parts of the same genus, if not species. It is more conducive to progress to record them, until proof to the contrary be had, as parts of *Dromornis australis*."†

To consider the femur from the Canadian lead as Pliocene, will not in any way invalidate Professor Owen's assumption, for the bird may have lived on from Pliocene to Post-Pliocene times. On the other hand, it equally lends colour to the existence of two species, and this will probably turn out to be the case.

III.—Remains of Dromornis.

(*a*) *Description of the Tibia.*—The bone forwarded from the Paroo River is the distal extremity of the right tibia of a bird, almost corresponding in size with the left figured by Sir R. Owen from the Mount Gambier Range, and referred to as *Dromornis australis*. The articular surface is more or less worn and somewhat decayed, especially the condyles, otherwise the fragment is well preserved. It has been obliquely broken as near as possible about the centre of the shaft, some distance below the position of the medullarterial orifice, as there is no trace of the distal termination of the fibular ridge. (Pl. XI, Fig. 1; Pl. XII, Fig. 1; Pl. XIII, Fig. 1.)

* Journ. R. Soc. N. S. Wales for 1877 [1878], xi, p. 43.
† Even this opinion was to some extent modified by Professor Owen only two years later. He said,—"One cannot, of course, state confidently that it," [i.e., the South Australian tibia] "is a bone of the same species of bird as the mutilated femur from the Cave of Wellington Valley, or of that from the drift at Peak Downs, in Queensland." *Mem. Extinct Wingless Birds, New Zealand, &c.*, 1878. *App.*, p. 6.

The bone has a dark blackish-brown appearance on the surface, a greyish hue at the fractured end, adheres strongly to the tongue, and effervesces slightly with acid. The anterior surface is deeply marked by the course of blood vessels.

The comparative measurements agree fairly well with those of Owen, bearing in mind the relative state of preservation of both bones. The dimensions of our fossil would appear to demonstrate that it was the tibia of a rather smaller individual than that referred to.

	Dromornis (Owen)		*Dromornis* (Paroo)	
	in.	lines.	in.	lines.
Transverse breadth of the shaft at the commencement of the distal expansion	2	2	2	1½
Transverse breadth of the shaft at the commencement of the distal condyles	3	5	3	0

The bone as preserved is eight and a quarter inches long, the broken proximal end of the shaft having a diameter of one and eleven-sixteenth inches, with a rounded oval section. The shaft is rather more compressed from before backwards than in the illustration of the Mount Gambier fossil, and does not expand very rapidly towards the condyles. A measurement taken across the precondylar groove, at that point which in *Dinornis* would be occupied by the "bridge of bone" gives two and six-sixteenth inches.

The inner condyle is the better preserved of the two, the outer being much decayed, and both exposing the porous structure of the bone. Judging the former, however, by its remaining portions, it would seem to be rather less in length, from before backwards, than the bone examined by Professor Owen.

The anterior surface of the shaft at its proximal end is flattened to some extent, but the posterior is more convex. The inner lateral surface is also flattened, or may be described as straight-walled, and is margined anteally by an extension of the distal extremity of the procnenial ridge, which is prominent, but obtuse.

There is an entire absence of roughening of the surface proceeding from muscular attachment, but on the contrary the surface of the bone is smooth fore and aft, and seamed with the meandering impressions of certain blood-vessels. On the anterior surface the most noticeable feature is the precondylar groove, which is traceable to within two inches of the broken proximal end of the shaft. At this point it is wide and shallow, gradually narrowing and increasing in depth, and at the same time curving towards the inner side. The shallow proximal end of this groove is quite contiguous to the inner lateral margin of the shaft, but as it progresses towards the fore part of the bone it takes up a median position, as described by Owen. The fossa, or deeper portion, between the commencement of the condyles, is more transversely obliquely placed and more open than in Professor Owen's figure of the left tibia. Its foramen is very much

larger than the corresponding pit in the right tibia of *Dinornis crassus*; and at the same time, there is a most marked difference between the fore and aft thickness of this bone, immediately above the would-be position of the bony bridge, and that in the first cited species. In *D. crassus* it is one and two-sixteenth inches, but in *Dromornis* the measurement reaches one and six-sixteenth inches, *i.e.*, a difference of a quarter of an inch. The pulley-like articular surface appears to me both flatter and wider than in the Mount Gambier tibia, but when compared with the similar part in *Dinornis crassus*, very marked differences are perceptible. The inner and upper ends of the condylar ridges on the posterior side approximate closely in *Dromornis*, but they do not do so in *Dinornis crassus*, the result being that the intercondylar space or channel is much narrower throughout the whole of its course in *Dromornis* than in *Dinornis crassus*. At any rate, this is particularly noticeable at the upper or proximal posterior end of the channel in the former bird. The rounded edge of the precondylar groove at that point in the present bone, whence in *Dinornis* the piers of the bony bridge, or oblique bar, would spring, are much worn away, and would at first sight convey an impression that a similar structure had here existed. By following the general contour of the groove, however, and comparing with this, the mechanism in a *Dinornis* tibia, it is quite apparent that such a structure could not have existed in the present instance, and we are therefore dealing with a true *Dromornis* bone.

On the outer lateral surface, between the upper edges of the anterior and posterior condylar margins there is an almost median depression; this also exists in *Dinornis*. On the contrary, in the Emu and in the Cassowary, this does not exist, but the surface of the bone is plain and more or less flattened.

The bone substance is thick, measuring at the proximal fracture six-sixteenths of an inch, the central cavity being one inch in diameter, and somewhat less in a contrary direction. Sir R. Owen compared the Mount Gambier tibia to the similar bone in *Dinornis elephantopus*, but the correspondence in size with the distal end of that of *Dinornis gravis** is most marked.

It is not my purpose to regard the small differential details which exist between the present bone and the left tibia from the Mount Gambior Range, as specific. Many writers on palæontological osteology would doubtless do so, but I think all purposes will be served if we look upon the present fossil merely as an addition to the structure of *Dromornis australis*.

(*b*) *Description of the Fibula.*—Associated with the bone just described is another fragment, which, with the assistance of Mr. Henry Barnes, Articulator to the Australian Museum, I have come to the conclusion is the proximal end of the left fibula. (Pl. XI. f. 2, Pl. XII. f. 2., Pl. XIII. f. 2.) In its present state it is three and a quarter inches long. The upper articular surface is worn almost

* Trans. Zool. Soc., 1873, viii, pt. 6, pl. 59.

flat and broad, in fact, much broader than in the corresponding portion of the fibula in *Dinornis elephantopus*. The outer cap of the head is sharp, and the same side retires inwards, forming a strongly concave surface. The "fore and aft" measurement of the head is two and fourteen-sixteenth inches, the transverse or cross measurement being one and three-quarter inches. In *Dinornis elephantopus* the corresponding proportions are two inches nine lines, and one inch three lines respectively, whilst in a bone of this bird now before me, they are two and three-quarter inches and one and two-sixteenth inches.

The inner side in *Dinornis elephantopus*, between the two extremities of the head, is roughly triangularly concave. In the Emu it is elongately concave, but in the present fossil the similar surface is limited, to some extent protuberant, and deeply and closely marked by pits for muscular attachment.

The posterior prolongation of the head is very marked and long, projecting backwards as an obtuse elongated process, and when compared with the similar part of the fibula of *Dinornis elephantopus* is at once seen to be less thick and massive, but more projecting. In the Ostrich there is a further diminution, and a still greater in the Emu.

The diameter of the shaft in *Dinornis elephantopus* is one and fourteen sixteenths of an inch, at a corresponding point to that at which our bone is broken. The diameter of the latter is only one inch, proving it to be a less powerful bone at this particular point. The antero-posterior width of our fossil, at the fractured end, is one and thirteen sixteenths of an inch, that of the bird used for comparison nearly as possible the same.

The tibial articular surface is not shown through the fracture taking place at the proximal commencement of the articulation, whilst the posterior edge of the bone corresponding to this, but immediately under the head, is very sharp and prominent.

The first point which strikes one is the generally more massive outline of this fibula than that of *Dinornis*, such as the gigantic *Dinornis elephantopus*, especially in the wider and larger head. The next peculiarity is the outer concave and smooth surface under the head, which is markedly different to the structure of the bone both in *Dinornis elephantopus*, and the Emu. As both the tibia and fibula were found in company it is but reasonable to suppose that they are closely related one to the other.

IV. Remains of Dromaius.

(*a*) *History.*—The late Mr. Gerard Krefft recorded the Emu (*Dromaius*) as a Post-Tertiary fossil,* and bones of this bird are in the Australian Museum from the Wellington Caves and other localities. More recently, my former colleague,

* Australian Vertebrata, recent and fossil, 1871, p. 37.

Mr. William Davies (late of the Geological Department, British Museum), described* the distal end of a mutilated tibia from the Wellington Caves, which is "interesting as being additional evidence of the still existing emu having been contemporaneous with the great extinct marsupials."

One of the most interesting points in connection with the occurrence of *Dromornis* at the Paroo River, is its association with *Dromaius*, thus lending colour to the belief of their co-existence.

(*b*) *Description of the Right Tibia.*—Amongst the Paroo fossils is the extreme distal end of the right tibia of an Emu, probably of a full-grown bird (Pl. XI., f. 4, Pl. XII., f. 3, Pl. XIII., f. 3). It presents certain peculiar modifications of structure, however, which are worthy of record. Chief amongst these is the great development of the extreme distal end of the shaft, as compared with the condylar portions. The following measurements will illustrate this:—

Name.		Measurement of the shaft at 1¾ inches above the condyles.	Measurement at the upper margins of the intercondylar surfaces.
Emu (living)...........	Long	1 $\frac{3}{16}$ inch	1 $\frac{14}{16}$ inch
	Short	$\frac{11}{16}$,,	1 $\frac{9}{16}$,,
Emu (fossil)	Long	1 $\frac{7}{16}$,,	1 $\frac{10}{16}$,,
	Short	$\frac{13}{16}$,,	1 $\frac{4}{16}$,,

That is to say, in the fossil tibia the shaft is much the larger and more solid (Pl. XI., f. 4), but in the recent bone the condyles and portions near them are by far the more massive (Pl. XI., f. 3). In the fossil the cavity of the shaft is $\frac{14}{16}$ in. × $\frac{8}{16}$ in., but in the recent bone these measurements are reduced to $\frac{13}{16}$ inch and $\frac{7}{16}$ inch. In both the thickness of the bone is the same, viz., $\frac{2}{16}$ inch.

A consideration of these details led Dr. E. P. Ramsay and the Writer to regard this bone as distinct from that of the Emu of Eastern Australia. But whilst engaged in this investigation, a paper by Mr. C. W. De Vis was read before the Linnean Society of New South Wales, "A Glimpse of the Post-Tertiary Avifauna of Queensland."† Amongst the specimens was the distal end of a left tibia, with rather more of the shank preserved than in the specimen now before me. Through the kindness of Mr. J. J. Fletcher, M.A., I was allowed to examine and compare this bone with that in our collection, with the result that to me they seem identical. Mr. De Vis has named his tibia *Dromaius patricius*, and as I am in accord with him in regarding it as a new species, I have much pleasure in adopting the name applied by him.

* Geol. Mag., 1884, i, p. 265.
† Proc. Linn. Soc., N.S. Wales, 1888, iii, pt. 8, p. 1277.

Mr. de Vis describes both the proximal and distal ends of the right tibia from separate examples, and the left coracoids. In regard to the distal part of the tibia, he notices the same peculiarities to which I have referred. The fossils are from King's Creek, "and with the exception of *Dinornis queenslandiæ*, nob., are the only bird bones which have reached the hands of the writer from that part of Darling Downs."

V.—Postscript.

A short abstract of this paper was published in the *Sydney Morning Herald*, of October 4th last; on the 5th instant, a letter appeared in the same newspaper from the Rev. J. E. Tenison Woods, stating that a discovery of the remains of an extinct Struthious Bird by him in 1866 took precedence of the determinations of the Rev. W. B. Clarke and Mr. Krefft, and complaining that his printed references to the same had been "ignored or passed over."

It is perfectly true that the rev. gentleman's references were overlooked, but not "ignored or passed over" in the sense his letter would imply, and the Writer is extremely sorry that the references mentioned were overlooked; it was, however a pure inadvertence.

It may not be out of place to examine briefly the statements contained in Mr. Woods' remarks on the bones believed by him to be those of the first recognized Struthious Bird in Australia. These will be taken in their order of publication, and commented on *seriatim*.

In the first notice* of these bones Mr. Tenison Woods says†:—"In sinking a well on the edge of a swamp, 14 miles north-north-west of Penola, some bones have been dug up, which were this day (April 25, 1866) recovered by me. They comprise two tibias and two tarso-metatarsal bones of some extinct and very large bird. The extraordinary length of the former bones, and the absence of any articular surface on the inner and posterior surface of the metatarsal bones show them to have belonged to some struthious bird very nearly allied to the emu. (*Dromaius ater*, Viellot ?); but as many osteologists are of opinion that specific distinctions cannot be determined by the skeletons of birds, this bird may have been something more than a mere species of emu. From the size of the bones it was evidently a larger, heavier, and more clumsy bird. The bones are both of right feet. The lateral surfaces of the three articular prolongations of the distal extremity are very concave; and at the extremity of the groove indicating the juxtaposition of the metatarsal pieces there is a large foramen extending from before backwards through the bone, perfectly enclosed on its inner side. In this respect the bone differs from our existing emu, in which the groove is quite open, prolonging the separation between the metatarsal pieces, and giving the external

* Report on the Geology and Mineralogy of the South-eastern District of the Colony of South Australia, &c.; p.p. 83 (8vo., Adelaide, 1866. Government Printer), p. 7.
† Page 7.

condyle a very long tapering appearance. In the fossil bone the condyles appear short, and stout, and very broad. I should propose the provisional name of *Dromaius Australis* for the bird until more bones are found. It is certainly quite extinct, but appears to have been contemporaneous with the natives, for these bones are marked with old scars, one of which must certainly have been inflicted by a sharper instrument than any in possession of the natives at present. There were, however, fragments of flint buried with the bones, and a native well is distant about 50 yards away."

In stating that the lateral surfaces of the three articular prolongations of the distal extremity are very concave, the author can only mean the free distal ends of the tarso-metatarsal bones. But the next sentence, "at the extremity of the groove indicating the juxtaposition of the metatarsal pieces there is a large foramen," is to the Writer unintelligible, unless the paragraph should read "grooves," of which there are of course two, the continuations of the interarticular spaces. The author then adds, "in this respect the bone differs from our existing emu, in which the groove is quite open." That is to say in the fossil bones a foramen exists, whereas in the emu it does not. I trust that my reading of the Rev. Mr. Woods' remarks is the correct one, because on the subject of the structure of the tarso-metatarsus of the Emu, as described by him, I cannot agree with him. In two skeletons before me the distal interarticular spaces between the metatarsals terminate in grooves, and the outer is interrupted in its course by a foramen, extending through the bone. How, then, can this constitute a difference between the fossil bone and the corresponding one of the Emu? As the only other difference pointed out, is that the condyles appear short, stout, and very broad, it becomes a question if the fossil bones might not have been those of an old individual of that species.

In his second series of remarks * the reverend author states:—"In 1865 the writer of this article found near a native well in South Australia the remains of another and much larger struthious bird, which had evidently been killed by the blacks in remote times. The provisional name of *Dromaius australis* was given to it, but since then its remains have been found in other places, and Professor Owen has named it *Dromornis australis*."

The third notice to be quoted reads:—"In 1866 I found the remains of a Struthious bird, much larger than the Emu, in one of the kitchen middens of the natives of South Australia. The bones were marked by the scrapings and cuttings of the flint knives of the blacks. I then stated that there was evidence that Australia had been formerly occupied by a wingless bird, much heavier and larger than the Emu, and I proposed for it the name of *Dromaius australis*. It has since been named *Dromornis australis* by Professor Owen, who has found that the bird had formerly a wide range in Australia." †

* Natural History of New South Wales—An Essay (p.p. 60, 8vo., Sydney, 1882. Government Printer), p. 27.
† Proc. Linn. Soc. N. S. Wales, 1883, vii., p. 387.

In the first place there is a discrepancy in the date of discovery of these bones as given in the first and second extracts. In the former it is 1866, in the latter 1865. In the second place the first account says these remains were found in "sinking a well on the edge of a swamp," but in the third notice in "one of the kitchen middens of the natives of South Australia." Now this discrepancy has a very strong bearing on the relative importance of these bones from a geological point of view, coupled with the assertion that they bear the marks of the natives' weapons. If found at any depth in sinking a well the geological antiquity is immensely increased, and greater colour is lent to the probability of the bones being those of a large extinct bird. On the other hand, the occurrence in a kitchen midden, brings them within the human epoch, lessens the likelihood of their relation to a large struthious extinct bird, and opens up a far more important question, which seems to have been almost lost sight of by the Rev. Tenison-Woods. In the first notice he says, "It is certainly quite extinct, but appears to have been contemporaneous with the natives, for these bones are marked with old scars, &c." The matter is also referred to in the second and third notices.

Granting, for the sake of argument, that the bones from South Australia are those of an extinct large bird, it appears to have escaped notice that we have here the first long-sought for evidence of the contemporaneity, on this continent, of man, and its former gigantic fauna.*

Finally, I would say a few words on the references made by the author to Sir Richard Owen. Mr. Woods says, "Professor Owen has named it *Dromornis australis*;" and again, "it has since been named *Dromornis australis* by Professor Owen, who has found that the bird had formerly a wide range in Australia." Will the author point out one single instance in the writings of Sir R. Owen on *Dromornis* to justify such a statement? There is not a particle of evidence to show that Sir Richard ever heard of Mr. Woods' discovery, saw his Report, or had before him the bones in question. What are the facts? The Rev. Mr. Woods in 1866 *names* two tibias and two tarso-metatarsal bones, *Dromaius australis*, from South Australia. Sir Richard Owen in 1872 *named*, and in 1873 *described* a femur from an alluvial deposit at the Peak Downs, Queensland, *Dromornis australis*, without any knowledge of Mr. Woods' previous discovery. Subsequently the same palæontologist described a tibia and referred to a pelvis, which he believed to be portions of his bird. The pelvis was from near Mudgee, the tibia from the Mount Gambier Range. Surely, had he any acquaintance with Mr. Woods' discovery, here would have been the opportunity to refer to it, when describing another bone from South Australia.

* This matter has been touched on by Mr. Woods since these pages have been in the printer's hands. (See *Queenslander*, 1888, xxxiv, No. 691, p. 1190.)

XII.—On the Stratigraphical Position of the Fish and Plant-bearing Beds, on the Talbragar River, Cassilis District, N. S. Wales; by WILLIAM ANDERSON, Geological Surveyor.

[Plate XIV.]

THE shales, containing fossil fish, discovered by Mr. Arthur Lowe, of Wilbertree, occur near the Talbragar River, about twenty miles in a straight line to the north of the old mining township of Home Rule, between Mudgee and Gulgong. Their exact position is marked by the southern boundary of Boyce's Selection, No. 14, Parish of Bligh, County Bligh, which passes in an east and west direction over the outcrop of the fossiliferous beds. The nearest point of the Talbragar River lies about three miles in a northerly direction from the locality where the fossils are found.

The general geological feature of the surrounding district is the prevalence of sandstone and conglomerate, which occurs as a bed of considerable thickness, overlying, with a slight unconformity, a series of sandstones, shales, and thin coals, which form some part of the Permo-Carboniferous system. These beds collectively never attain any great thickness in this district, and, when worn through by denudation, the older Palæozoic rocks on which they rest are exposed. This superficial layer of sandstone and conglomerate forms a horizontal bed, showing false bedding, and no doubt represents the Ballimore, or Dubbo Sandstone of the west, and the Hawkesbury Sandstone of the eastern seaboard. The variation in the thickness of the Coal-measures in this part of the western district is purely local, being due to the irregularity of the surface of the Silurian bed-rock on which they were laid down. Frequently the Silurian rocks are seen to rise so high as to be in close relation to the lower surface of the horizontally bedded sandstone overlying the Coal-Measures, which, in such localities, are very thin or not represented at all; so that, although the whole district has been uniformly covered by the Hawkesbury or Dubbo Sandstone, except in a few localities where the Silurian rocks had been so elevated that they rose as shoals or islands in the Triassic sea, the Coal-Measures on which it rests, only attain a considerable thickness over isolated areas, where there had been depressions in the Silurian bed-rock which formed the surface on which the Coal-measures were deposited.

In the eastern district there occurs, intercalated between the Coal-Measures and the Hawkesbury Sandstone, the Estheria and Narabeen Shales, which latter, as suggested by Mr. C. S. Wilkinson,* may probably be the southern representative

* Notes on the Geology of New South Wales, by C. S. Wilkinson, F.G.S.—*Mineral Products of New South Wales*, 1887, p. 71.

of the Clarence Series. In the west these two series of shales are not present, and the frequent occurrence of *Glossopteris* in the shales among the coal-bearing beds below the Hawkesbury Sandstones, both here and in the Dubbo district, would preclude the possibility of their being the equivalents of the Clarence Series, for, so far as it is at present known, *Glossopteris* has not been found to occur in the latter. It seems to me probable that these western Coal-measures, which occur in the basin of the Talbragar River, are the equivalents of some portion of the upper part of the Newcastle Series.

In the immediate neighbourhood of Boyce's selection there are patches of Tertiary basalt of limited extent, in connection with which occur small deposits of exceeding well-rounded, polished, and water-worn pebbles, chiefly of quartz and a dark siliceous rock containing the remains of plants. This basalt and drift rest upon the horizontally bedded sandstone and conglomerate, but do not (at least now) cover the shales containing the fossil fish.

The fossils which first attracted attention were the impressions of plants, which occurred frequently in the loose blocks of shale which lay scattered over the surface of the hill. Subsequently, the fish remains were discovered occurring along with the plants, and, on closer examination by Mr. Arthur Lowe and his brother, they were found to be quite a common feature in the beds, in fact, of more frequent occurrence than the plants.

When I visited the locality, in the beginning of December, 1888, under the guidance of Mr. Lowe, of Wilbertree, I found that only the detached blocks, sticking in the soil had been broken open, the beds themselves not having been touched; but nevertheless great numbers of specimens were obtained and lay ready for transportation; in fact, these specimens form a large portion of this valuable collection.

The shales in which the fossils occur are thinly-laminated, fine-grained, and ferruginous. When unweathered they are grey in colour, and when weathered light brown, which is due to the decomposition of the contained ferruginous material. The joints and laminæ are frequently covered with dendrites. The results of the weathering of these shales are somewhat peculiar. When fresh, the rock seems to be quite compact, without any visible signs of jointing or lamination, but immediately the weathering action begins, it first picks out the vertical jointing, along which the ferruginous decomposition travels, and from these it passes along the laminæ, and so gradually diffuses itself throughout the rock. Many of the blocks when split open show this progressive decomposition very well, where a vertical joint may be seen marked out by decomposition, which may have travelled half-way across the slab. When unweathered it is difficult to split the rock into laminæ; but after considerable weathering it splits easily into square or

rectangular layers, often very thin. The final result of this decomposition is, that each rectangular block, formed by two parallel sets of vertical joints at right angles to each other, shows a concentric colour-banding parallel to the vertical jointing, and consisting of lighter and darker ferruginous layers, which traverse the rock at right angles to its lamination. This discolouration which the rock undergoes, does not materially affect the fossils, which are sometimes of a white colour, and are fairly well preserved As a rule, the bony skeletons of the fish are the only parts remaining, although, in numerous cases, the impressions of the scales, showing their ornamentation, can be readily seen. They are mostly of small size, being, as a rule, only a few inches in length, although a few specimens of larger size occur.

One specimen of peculiar interest was obtained by the Collector, Mr. C. Cullen. It was a very perfect example of an insect, which has been beautifully preserved, and forms one of the earliest evidences of terrestrial insect life that have yet been discovered in Australia.

On no part of the outcrop is there a clear section of the fossiliferous beds, showing their relation to the surrounding sandstone and other rocks. But after a careful examination of the ground, I am inclined to think that what little stratigraphical evidence there is, points to the conclusion that they form an isolated lenticular patch in the horizontally-bedded sandstones, similar to the lenticular beds of grey shale which occur in the Hawkesbury Sandstone near the coast. If this be so, the fish, plant, and insect remains are of Hawkesbury or Triassic age, and, consequently, they belong to the same period as the large collection of fish which were obtained some time ago at Gosford, on the Northern Railway, between Sydney and Newcastle. The present collection of plants and fish from the Talbragar River will form another important addition to the, as yet meagre remains, of the fauna and flora of the Hawkesbury-Wianamatta Series, and will have a special interest from the fact that they are from the extreme western portion of the Hawkesbury basin, where the deposition of the sediment must have taken place in much shallower water than was the case in its eastern portion, from which the Gosford fish were obtained.

Great praise is due to Mr. C. Cullen, who made this large collection under considerable difficulty.

XIII.—On the Examination of an Aboriginal Rock-shelter and Kitchen-midden at North Harbour, Port Jackson; by T. W. EDGEWORTH DAVID, B.A., F.G.S., Geological Surveyor; and R. ETHERIDGE, Junr., Palæontologist.

[Plates XV–XXII]

A ROCK-SHELTER and Kitchen-midden on a small bay at North Harbour called Forty Baskets, and nearly opposite the town of Manly, had been partially investigated by Messrs. P. R. Pedley and J. Davison, when it was suggested that we should follow up their work in a more systematic manner.

North Harbour, like the other inlets of Port Jackson, is formed by the Hawkesbury Sandstone, the shore at the small bay known as Forty Baskets, having a trend of S. 36° E. The margin is here fringed with a foreshore of sand, which, in the bight of the bay, thins out completely against the sandstone, but to the north-west, at the mouth of a small creek, it attains a width of three chains. The distance between the creek and the bight of the bay is one hundred and sixty-six yards. Along this line the Hawkesbury Sandstone rises from the south-west to an altitude of one hundred feet in a distance of about one hundred and thirty yards. At thirty yards back from high water-mark, and forty feet above it, is the floor of the small cave or shelter-rock, its position with regard to the several points being shown on Plate XV.

The kitchen-midden forms a small part of the small flat around the mouth of the insignificant creek at the north-eastern angle of Forty Baskets Bay. It is from sixty to seventy yards long on the south side of the latter, the inclination of the surface, from the foot of the sandstone rise to high water-mark, being a very gradual one (Pl. XV).

The rock-shelter (Pl. XVI, Figs. 2–4) is an overhanging ledge of Hawkesbury Sandstone, facing the north-east, and projecting from the rocky and somewhat steep slope.

The roof consists of a hard bed of sandstone from five to six feet thick, which, owing to the softness and consequently more rapid disintegration of the underlying stratum, has become considerably undercut in places, so as to roof-in sheltered spaces, of which the one now under consideration is sixteen yards long, from six to seven feet high in front, and two to three feet high at the back (Pl. XVI., Figs. 2 and 3). The roof of the cave is much blackened and begrimed with the soot from the smoke of numerous fires; for, to judge from the thick accumulation of ashes

on the floor of the shelter, this spot must have been a haunt of the aboriginals for many generations. The roof has a slight dip of about two degrees to the south-east, which is the same as that of the surrounding strata.

The original rock-floor is exposed at its west-north-west end, but towards the east-south-east is covered by an accumulation of refuse material left by the aboriginals, twenty and a half feet long, five feet wide at the west-north-west end, and eleven feet at the east-south-east, at which latter point it is at least two feet thick (Pl. XVI., Fig. 2). This refuse material consists of light grey dusty ashes composed of lime formed from burnt shells and fine charcoal, with a small proportion of sand; and, scattered through the whole mass, though most numerous in the upper nine inches of it, are various edible shells, most of which are fractured and some partially burnt.

The following is a descending section of this deposit at the point where the first skeleton was found by us:—

ft.	in.
0	4.—Light grey very loose dust, composed chiefly of burnt lime, charcoal, and a little sand, with edible estuarine shells.
0	5.—Dark grey sandy humus, with shells similar to the preceding.
0	5.—Dark grey loamy sand. The skeletons were buried chiefly in this layer, and reposed on the underlying one.
1	0 (at least).—Dark brown consolidated sandy loam.

The whole of the soil in which the skeletons rested was interlaced with the roots of a tree, *Acacia longifolia* (Pl. XVII.), the trunk of which was twelve inches in diameter near the ground, and six feet distant from the skull of the first skeleton. The tree was thirty-five feet high.

The north-end of the Rock-shelter had already been explored before our attention was called to it, but the southern end was intact, and to this our researches were confined (Pl. XVII. Fig. 2). The whole accumulation within the shelter consisted of fine pulverulent lime and ash-dust mixed with a proportion of humus and fragments of recent species of littoral shells, such as were used by the blacks as food.

The bones found in this deposit were, generally speaking, in poor condition, and some were intermingled and confused, as if disturbance subsequent to their original deposit there, had taken place. The friable condition of some can probably be accounted for by the quantity of lime contained in the enclosing earth, and the heat which the whole mass must have been subjected to during long habitation. We found here the larger portion of a male skeleton, originally placed in a prone position, but so intermingled with the rootlets of the acacia, previously mentioned, that the bones were with difficulty removed. The skeleton was cut off from the

remainder of the shelter by a large stone placed alongside, not above, the depth below the present surface of the deposit being not more than nine inches to one foot. The skeleton was lying obliquely downwards, the head lowest, the thigh bones at right angles to the column, and the arm bones tucked under the lower jaw. Those portions removed in anything like a perfect state were the larger limb bones, some of the vertebræ, portions of the pelvis, bones of the feet, and parts of the skull, with the teeth exceedingly worn. With these were split kangaroo bones, and a small siliceous flint instrument. The ash deposit surrounding the skeleton contained burnt bones, and the shells, some partially calcined, of *Mytilus hirsutus*, Lamk.; *Cypræa vitellus*, Linn.; *Patella stramoserica*, Martin; *Trochochoclea zebra*, Menke.; *Nerita melanotragus*, E. A. Smith; *Anomalocardia trapezia*, Desh.; *Minella straminea*, Martin, and *Ostrea maudax*, Gould. Three of the leg bones bear very peculiar markings, which will be referred to later (Pl. XX. Fig. 1). In addition to the skeleton of this man other odd bones and pieces, portions of the skeletons of two other individuals, were found by examining the bulk of the ash deposit, prominent amongst these being a lower jaw almost intact, again with the teeth very much worn down, but quite sound.

The deposit on the shore below, and a little to the north of the Rock-shelter is very different to that of the latter. It consists of a mixture of loam, sand, and charred particles, mixed with broken and decayed shells. The thickness of this deposit does not exceed four feet, and rests on dirty sand.

Immediately above high water-mark on this flat, Mr. P. R. Pedley, on a former occasion found two burials, those of a girl and deformed man, accompanied by a tomahawk and skinning knife, similar to those found by us at Long Bay, near Botany. These interments were covered with large stones in the usual way.

Under the guidance of Mr. Pedley, and with the assistance of Messrs. Shipway and Davison, we commenced trenching operations a little to the south-west of the above graves, and, after a considerable amount of labour, we came upon several covering stones, about nine inches below the surface. Under these we found the skeleton of a full-grown man in a fairly good state of preservation, lying in a north-east and south-west direction, on the left side, and so facing the south-east, but more or less doubled up, the femora being partially drawn up against the body. As lying on its side, the skeleton measured five feet in length, so that allowing for a reasonable contraction, this must be the remains of a fairly big man. It was complete with the exception of the left femur and the arm bones. As in the case of the shelter remains, pieces of split bone, probably kangaroo, were also found, and under the skeleton another small siliceous knife (Pl. XX, Fig. 2*a*).

The bones of the man collected here by Mr. Pedley have not come under our notice, with the exception of the left femur, two tibiæ, and the two humeri, the right being much the thicker and stronger bone. These have been presented by

Mr. Pedley to the Mining and Geological Museum. Those portions of the girl's bones remaining at this date, consist of parts of the skull and jaws, both os ilü, parts of ribs and vertebræ, both fibulæ, an ulna, and other fragments. The epiphyses of the limb bones are unossified, and the teeth, especially the molars, retain the original sharpness of their crown convolutions. This would imply that the bones were those of a young person. These have also been presented by Mr. J. Davison.

Returning to the skeleton exhumed by ourselves, we find that the bones do not call for special comment, with the exception of the skull, and this only in so far as its connection with the position in which the deceased had been put to rest. We have already remarked that the arm bones were missing. But on lifting the head we found the left hand nearly perfect, placed under it, in the most natural position (Pl. XXII), as if the man had been reposing in sleep, with his head resting on the hand. The bones are in apposition with the fingers partially pressed into the orbit, but the terminal digits are wanting. This fact struck us as of so very interesting a nature that steps have been taken to preserve both head and hand in their original state (Pl. XXII).

On the overhanging face of the Hawkesbury Sandstone, forming the roof of the shelter, are what may be termed splash work representations of two human hands, both left hands, so often scattered about places frequented by the aborigines. In this case the hands are represented with the palms pressed to the rock surface, the fingers pointing towards the general expanse of the shelter (Pl. XIX). They are situated at the extreme left-hand, or east-south-east end of the excavation, and when delineated, each was placed obliquely, the thumb being held more or less horizontally, and forming the base line of the figure. The area of rock covered by the hand at the time the work was done, retains the original dark grey colour of the smoke-begrimed roof, while the surrounding rock has been splashed or sputtered over with the ashes from the floor of the shelter, so as to produce a light grey ground, contrasting with the dark grey of the hand. The extreme size was six inches from the thumb-bases to the apices of the fingers, and five inches across the palm and thumb in each case. The hands are eleven inches apart, and each about five feet eight inches above the floor of the shelter.

On a contiguous knoll, or rise, rather more than one hundred and twenty yards to the south-east, and overlooking the entrance to North Harbour, several rounded bosses of sandstone crop out, bearing rude aboriginal sculptures (Pl. XXI). These have much decayed, and the only ones discernable are represented in this plate. Of them, Fig. 2 is the plainest. The longitudinal subdivision down the middle is apparent, and two horizontal bands in the contrary direction. The size is two feet seven inches by one foot three inches, the indented outline being three quarters of an inch thick. The outline is somewhat angular

on the left-hand side, and the longitudinal subdivision forks both above and below immediately before its final termination at both ends. The second (Pl. XXI, Fig. 1) is somewhat larger, being two feet eleven inches by one foot six inches, but is precisely similar, with the exception that the centre transverse bands are wider apart and curved. In the third carving (Pl. XXI, Fig. 3), we notice a much more oval outline, a far smaller size, and the crossbars, as in Fig. 2, far apart. These carvings are regarded by some as representing boats, by others fish; but they have quite as much resemblance to shields. It is possible they may be the totemic emblems, or boundary marks of the tribe then frequenting this part of the shores of Port Jackson.

The implements found with these skeletons are few in number but interesting. In the Rock-shelter the only object discovered was a siliceous chip (Pl. XX, Fig. 2). A similar object was also found in the Midden excavation on the shore (Pl. XX. Fg. 2*a*). In both cases the position of the chips was identical, underneath the skeletons of the men. Associated with the remains of the girl and deformed man, exhumed by Messrs. Pedley and Davison, was a small tomahawk, oblong in shape, but without a sharp cutting edge. A portion of another and larger axe accompanied this, obliquely split in half (Pl. XX, Fig. 4). Both were originally travelled pebbles, not representing local rocks, and would seem to have been in course of preparation. They are a hornblendic quartz porphyry. A flat skinning-knife, of Hawkesbury Sandstone, similar to that found by us at Long Bay,* but smaller, was also present; and so was another implement, of the same rock, oval-pointed in shape, and perhaps used for piercing, or it may even be as an ornament (Pl. XX, Fig. 3). Similar implements to this have been obtained by Dr. E. P. Ramsay, from aboriginal interments, in Eastern Australia, but he is unable to suggest their use. The siliceous chips above referred to (Pl. XX, Figs. 2 and 2a) are possibly the knives used for making flesh incisions to raise scars, or may even be circumcision knives. Mr. John Brazier has seen similar chips from Western Australia which were undoubtedly used for the latter purpose.

A number of illustrations of chips used for various objects are given by Mr. R. Brough Smyth,† such as used in making jagged spears, cutting scars, skinning and dressing animals, and fragments struck off in preparing tomahawks. Those now under description, however, appear to us to have been employed in one or other of the former operations.

We have already mentioned that some of the bones taken from the rock shelter bore markings. In Pl. XX., Fig. 1, the left tibia of the prone skeleton, taken from inside the projecting stone is represented. It will be observed that the shin-ridge at its proximal end is transversely corrugated and apparently eaten away. Close

* Records Geological Survey, N.S. Wales, I. Pt. I.
† Aborigines of Victoria, 1878, I., pp. 380-382.

inspection shows how very tooth-like these markings are, a few exhibiting a prolonged scar, as if a sharp-pointed edge had been drawn across the bone transversely. We have considered the origin of these indentations from various points of view, whether the work of man, the dog, or any smaller carnivorous animal. It would hardly have been possible for a dog's teeth to leave such marked impressions on a green bone; nor, indeed, do the scars correspond to the teeth of that animal. But a suggestion of Dr. E. P. Ramsay's is probably much nearer the truth, that these indentations are the result of gnawing by rats. This will, in a great measure. coincide with the more or less undisturbed condition of the tibia when found. We also took into consideration the possibility of these markings having been caused through the agency of man, either as a cannibal or by means of a tomahawk; but both views were dismissed as untenable with the evidence at hand.

XIV.—Remarks on a Fern (*Cycadopteris scolopendrina*, Ratte), from the Wianamatta Shales, near Sydney; by R. ETHERIDGE, Junr., Palæontologist.

[Plate XXIII.]

MR. FELIX RATTE has recently described* a new fern from the Wianamatta shales, which he provisionally referred to the genus *Cycadopteris*, Zigno, under the above name. Mr. Ratte hesitated in the choice of a genus for this plant, between that just named and *Lomatopteris*, Schimper, through the imperfection of his material. The acquisition of a more perfect specimen by Mr. G. A. Stonier, Field Assistant, enables me to supplement Mr. Ratte's description.

In both *Cycadopteris* and *Lomatopteris* the rachis is thick, and naked or winged, the pinnules simple or lobed, decurrent, and more or less confluent, but as regards this last character, less so in the former than the latter. Lastly, in both genera the edges of the pinnules are thickened, but here the resemblance ceases.

In *Lomatopteris* there is but a primary nerve in each pinnule, thick and strong at the base, and insensibly decreasing towards the apex, which it hardly reaches, whilst secondary nerves are quite absent. In *Cycadopteris* on the other hand, both primary and secondary nerves exist. The former, as in the first, are large and thick, holding their size nearly to the apex of each pinnule, where they break up into two or three branches. Like that of *Lomatopteris*, it is more apparent on the inferior surface, but is represented on the upper by corresponding grooves. The secondary nerves are short and bifurcate.

* Proc. Linn. Soc. New South Wales, 1887, I. pt. 4, p. 1081.

In the description given by Saporta it is difficult to understand the distinction he draws between the marginal thickening of the pinnules in the two genera. In the case of *Lomatopteris*, he says,* they are always thickened by a continuous marginal fold, whilst those of *Cycadopteris* are thickened by a line (*ourlet*), which does not proceed from a fold, but is formed by a flat and cartilaginous beading (*bourrelet*). It is difficult to detect an appreciable difference between these characters.

Mr. Ratte's specimen did not show any trace of secondary nerves, but from the general habit and undoubted apparent similarity to *Cycadopteris*, he provisionally referred it to that genus. The acquisition of the present specimen enables me to support Ratte's determination, for there are decided, although faint, traces of secondary nerves. Our specimen exceeds the original in size considerably. The latter is five inches in length by one and a quarter in breadth, the former is eight and a half inches long by two and a quarter wide. It exhibits twenty-eight pinnules, wholly or in part, on one side, and twenty-six on the other. The rachis is three-sixteenths of an inch wide, whilst the pinnules are on an average one inch long and five-sixteenths wide at the upper end of the pinna, but only three-quarters of an inch in length at the basal portion. In form they are oblong ovate, incised for about one-fourth of their length, but the incision strongly marked, the free edges being indicated by a very apparent delicate border. The central groove, representing the mid-rib of the superior face, is wide and shallow.

Locality and Horizon.—Abel Harber & Co.'s brick works, Alexandria, near Sydney. Wianamatta Shales, 120 feet above the Hawkesbury Sandstone.

XV.—Report on supposed Caves, with Aboriginal Drawings, on Harris' Creek, and George's River, near Liverpool; by R. ETHERIDGE, Jun., Palæontologist.

[Plate XXIV].

THE first "Cave," which is simply an overhanging Rock-shelter, is situated on the west side of the western branch of Harris's Creek, a tributary of George's River, and one and a half miles south-east of Teesdale's farm (formerly Andrew Moffitt's), Portion No. 18 (c. 19), of the Liverpool Land District, and about ten miles south-east of that township.

* Pal. Franç., Plantes Jurassiques, 1873, I., p. 392.

The shelter is perhaps fifty feet above the creek bed, in an ordinary rocky escarpment of the Hawkesbury Sandstone. The direction of the scarp is about S. 5° E., the dip of the sandstone about N. 50° W., at an angle of 25°. The length of the shelter is eighty-seven feet, and its height from the floor to the upper edge of the scarp only twenty-two feet. It is a shallow rocky-hollow of two portions, a right and left as the spectator faces it. The former depends for its outline on the dip of the sandstone; the latter has been gradually hollowed out by atmospheric disintegration. On the surfaces of the dip-faces are a number of rude figures, in black charcoal outline, shaded within their margins. Amongst them are discernable an emu, a shark, several smaller fish, and a figure much resembling a *Hippocampus* or sea-horse, but no hands. Some of the figures are drawn on the dip-face of the roof, quite in the angle formed by the union of the latter and the floor, and must have been executed by a draughtsman lying on his back.

On the face of the left-hand portion of the shelter are delineated a dog, fish, birds, and other indistinct objects, with some hideous outlines, more or less human in shape, probably intended to convey the idea of a "devil-devil." Under some portions of these drawings, and produced previously to them, are seven "hands" of the usual type, in all cases the left; each hand of the dirty yellow colour of the surrounding sandstone; but the surface of the latter outside the margin of the figures with the peculiar ashy or smeared appearance usually accompanying these strange signs.

It was stated by Mr. J. W. Brown, of Liverpool, who acted as guide, that his father, Mr. J. D. Brown, was acquainted with the figures fifty years ago, say about 1838, when he was in the habit of frequenting the creek in company with the aborigines.

The floor of the shelter is, in places, sandstone *in situ*, in others, disintegrated sand, but too shallow to allow of burials having taken place.

Now it would appear from the presence of the "hands," which are *genuine*, that this was formerly a Rock-shelter of the blacks, but the drawings in their *present condition* are *spurious*. The charcoal outlines are quite fresh, and correspond in every way with the initials and hieroglyphics of recent visitors, scattered amongst and alongside the drawings. But there is the great probability that these are original drawings touched-up. This opinion is founded on the fact that here and there undoubted outlines, of an older condition, can be traced where the more recent black ones have not accurately followed the older, a view in which I have the support of Dr. J. C. Cox, who formed one of the party. The older outlines were probably executed in black, like the more recent, but have become almost obliterated.

After inspecting this shelter we were conducted to the east side of George's River, on G. Garnock's Portion 59 (C. 50). Here, close to the mouth of a gully running through Portion 92 (C. 699), another shelter was examined in the rocky escarpment of the river. This is seventy feet long by twenty-two feet deep, and ten to fifteen feet high, and is similar in character to that just described. There are no hands visible in this case, and the natural decay of the rock has almost obliterated what drawings there are. They are of precisely the same character as those in the shelter at Harris's Creek, but quite unimproved, and are only visible in dim outline. This, to a great extent, supports my view that the former are original drawings touched-up. The objects delineated are fish, a kangaroo jumping, and the same humanized figure already described.

The conclusion, therefore, to which one is lead are:—That the open hands are the work of aboriginal artists. That the other figures are of considerable age, as evinced by Mr. Brown's statement; but whether executed by the blacks, or some early white living with them, it is difficult to say, but most probably the former. Finally, those in the Harris's Creek shelter have been improved comparatively recently.

DEPARTMENT OF MINES, SYDNEY.

RECORDS

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XVI.—On the Occurrence of the Genus *Meiolania* in the Pliocene Deep Lead at Canadian, near Gulgong: by R. Etheridge, Junr., Palæontologist.

[Plates XXV and XXVI.]

So far as I am aware neither the remains of the large extinct Lacertilian *Megalania (? Varanus) prisca*, Owen, or either species of the horned Chelonian *Meiolania* have so far been found in any of the New South Wales Pliocene or Post-Tertiary deposits. Both genera were met with in accumulations of the latter age in Queensland, and the last named at Lord Howe Island.

During a preliminary examination of some vertebrate remains from the Canadian Lead, Gulgong, presented to the Mining and Geological Museum by Mr. Philip Snayse, of Gulgong, I was struck by the number of bony plates which appeared to be broken fragments of a Chelonian carapace. Amongst these, however, four bones awakened the keenest interest, from their instantly recalling corresponding portions of the bony framework of Sir Richard Owen's genus *Meiolania*. The specimens are a small horn-core, the greater part of a caudal vertebra, and two portions of two of the annular segments of the tail-sheath.

The controversy over the affinities of these highly interesting genera has been admirably epitomised by Mr. A. Smith Woodward *, and the synonomy corrected. From his remarks it appears that the name *Megalania* must be restricted (if indeed

* Ann. Mag. Nat. Hist., 1888, I., p. 85.

the bones so named are distinct from *Varanus*) to Lacertilian vertebræ from the drift deposits of Darling Downs, and for which it was originally proposed.* On the other hand, the Queensland horned skull, hypothetically placed with these Lacertilian vertebræ, must be transferred to Owen's later described genus *Meiolania* †, created specially for a like skull from Lord Howe Island.

The *horn-core* (Pl. XXVI, fig. 4) is a small bone, measuring exactly $1\frac{4}{16}$ inches in both directions with a basal diameter of $1\frac{8}{16}$ inches, the base having an expanded flange-like appearance. The anterior margin of the base is rather convexly curved, the posterior more concavely excavated. The apex of the core is blunt, and compressed laterally, the entire core being but little curved in a vertical direction, but when placed in a natural position on its base, there is a decided inclination backwards. The surface is deeply and strongly pitted and grooved with neuro-vascular markings. This horn-core corresponds in miniature with the cranial cores of the *Meiolania Owenii*, Smith Wood. ‡, or the smaller ones of *M. platyceps*, Owen. ‖

The two portions of the *annular ring of the tail sheath* (Pl. XXV, fig. 2, Pl. XXVI, fig. 2) are probably derived from the anterior end of the tail as they do not show any sign of having formed a portion of the anchylosed terminal cap. One bears a single boss, the other carries two. These are blunt and conical processes, with their posterior faces vertical and abrupt. Both bones are equal in size, although differing in outline, and measure $2\frac{1}{16}$ inches in breadth, by $1\frac{1}{2}$ inches in length. The thickness of the bone of the former along the posterior edge at the centre of the boss or core, is half an inch, gradually tapering away in a smooth convex surface to the almost sharp anterior margin. These processes are rather different in shape to those on the tail of *Meiolania Owenii* § being more depressed and less protuberant. The second annular fragment (Pl. XXVI, fig. 2) is actually composed of portions of two quadrangular pieces similar to that bearing the one process (Pl. XXV, fig. 2), but with the lateral margins broken away. The line of suture between these two halves is visible, and this may perhaps answer to the "line of confluence" spoken of by Prof. Owen on the upper surface of the tail-sheath of *M. Owenii.*

The caudal vertebra will be at once understood by a comparison with the anterior of those preserved *in situ* in the end of the tail-sheath of *Meiolania platyceps* (Pl. XXV, fig. 1). This exhibits the vertebræ in a much better state of preservation than the corresponding figure given by Sir Richard Owen. When viewed from below, or to some extent sideways, the vertebra is seen to be somewhat hour-glass-shaped, roughly biconate, with the apices towards one another, and

* Phil. Trans., 1860, cxlix, p. 43.
† *Ibid*, 1887 clxxvii, p. 471.
‡ Owen, Phil. Tran., 1881, clxxii, t. 64.
‖ *Ibid*, 1887, clxxvii, t. 30.
§ *Ibid*, 1881, clxxii, t. 64.

sharply constricted by a transverse band in the middle line. It is broadest posteriorly. The centrum is opisthocœlous, roundly ellipsoidal at either end, both the anterior convex, and posterior concave surfaces being well marked; the broadest end of the ellipse is uppermost. The neural ridge is cristiform, thickened posteriorly where overhanging the canal, but tapering off towards the anterior, and becoming sharper. In the present example the apophyseal surface, showing attachment to the exoskeleton is fractured. The neural canal is nearly oval, with a low central ridge on the floor, and extending the whole length. The transverse apophyses, or as they are termed by Owen "buttresses," here partially broken away (Pl. XXV, fig. 3), are confined as in *Meiolania platyceps* (Pl. XXV, fig. 1) to the posterior half of the vertebra. The lateral surfaces of the anterior half of the vertebra are somewhat rounded.

The hæmal surface is much curved in its antero-posterior length, cut out in the middle line, and V-shaped grooved along its posterior course. The anterior end is rounded off, but as the bone at this point is abraided, it is possible that it also may have been grooved, similar to that of *Meiolania platyceps.* This division of the hæmal portion of the bone now under description, would appear to represent the chevron bones of other groups of the Reptilia, and in more perfectly preserved specimens would form hæmapophyses, or buttresses, for the support of the ventral surface of the bony tail-sheath, or exoskeleton. This is, in fact, well shown at the anterior end of the fracture in the figured tail-sheath of *Meiolania platyceps* (Pl. XXV, fig. 1), from Lord Howe Island.

The general structure of this vertebra from the Canadian Lead, is quite that of the above tail vertebræ of *Meiolania*, but in all probability it would occupy a much more anterior position than any of those here illustrated. Specific identity must remain an open question until we become acquainted with the similar vertebræ of *M. Owenii* and *M. platyceps.**

Glancing for a few moments at the tail-sheath from Lord Howe Island (Pls. XXV and XXVI, fig. 1), we observe that the neural and hæmal spines do not seem to show that amount of expansion at their confluence with the sheath anticipated by Prof. Owen. It is a similar osseous subcylindrical sheath to that figured by the latter, with an upper and lower pair of caudal horn-cores, but with the various parts in a more complete state. Owen's specimen was only "sufficiently well preserved to show the elongate subcylindrical shape of the vertebral body, and the reduced area of the neural canal."

* Since these *Meiolania* remains first came under my notice, I have received from Mr. A. G. Hamilton, of the Public School, Mount Kembla, a Chelonian cervical vertebra, obtained from the Canadian Lead. It is, to some extent, imperfect, but, nevertheless, a fair-sized bone, and would appear to be the fifth in the series. As we are not yet acquainted with the similar bone in *Meiolania*, I refrain for the present from referring the specimen to that genus.

In Pl. XXV, fig. 3, these points are also visible, with the supporting buttresses of the exoskeleton, and a more complex "bridge of bone" over-arching the neural canal.

In addition to the remains of *Meiolania* herein described, the Mining and Geological Museum has been enriched by the presentation of many fragments of the carapace and plastron of at least one species of fresh water turtle, perhaps more, from the Canadian Lead. The plates resemble those of the existing *Chelodina*, and amongst the specimens can be recognized marginal carapace pieces, and the right and left pectorals and abdominals of the plastron. They compare most favourably with the similar plates of *Chelodina sulcifera*, Gray, an existing Australian species.

The Canadian Lead, from which the subjects of Pl. XXV, figs. 2 and 3, and Pl. XXVI, figs. 2–4, were obtained, is situated about four and a-half miles from Gulgong, near Mudgee. The length of this lead where worked was 4,660 feet, and the width that proved payable, was from 300 to 500 feet. The sinking averaged about sixty-five feet deep.

Speaking of the Upper Tertiary Leads of this district, Mr. C. S. Wilkinson says: "At a period when the deep leads, such as the Black, Moonlight, Caledonian, &c., formed the drainage channels of the country, and when the banks of those ancient streams were covered with luxuriant vegetation, amidst which the gigantic Diprotodon and other (now extinct) animals found genial pastures, an outflow of lava from some point of eruption came flowing down from a northerly direction . . . covering up the leads as far as the level of the ground would admit it. . . . . Some of the molten basalt spread up the valley for about a mile, while the rest flowed down it in a semi-fluid mass, about 150 feet thick, partly filling the valley for some 20 miles further on. . . . . In most of the leads vegetable fossils, trunks of trees, leaves, nuts, ferns, &c., are found. In the auriferous gravel in Black Lead, beneath the basalt, at a depth of 160 feet, and also at Home Rule, at 130 feet, these fossils are very abundant."*

The remains of *Meiolania Owenii* from Queensland, were found in alluvial deposits, probably of Post-Tertiary age, whilst those of *M. platyceps*, from the Coral-sand rock of Lord Howe Island, are certainly of that age. The present bones, however, must, from their stratigraphical position, be referred to the period of the Pliocene Gold Drifts, and are the oldest known remains of *Meiolania* yet discovered.

* Annual Report, Department of Mines, New South Wales, for 1876 [1877], p. 171.

XVII.—The Leucite-basalts of N. S. Wales: by T. W. EDGEWORTH DAVID, B.A., &c., and WILLIAM ANDERSON, Geological Surveyors.

[Plates XXVII and XXVIII.]

I.—Introduction.

LEUCITE, as a rock-forming mineral, is of very restricted occurrence. It is present as an essential mineral in leucitophyres (sperones), leucotephrites, and leucitites, and as an essential or accessory mineral in some basalts, trachytes, and phonolites. When leucite is so abundant in the three last-mentioned rocks as to form a distinguishing characteristic, the term leucite is added as a specific or varietal prefix to the generic term basalt, trachyte, or phonolite.

So far as is at present known its occurrence is chiefly, if not wholly, confined to lavas of subaerial or subaqueous origin.

Leucite rocks, although widely distributed, occupy a very small superficial area, being restricted to small isolated lava-sheets in localities far distant from one another, and few in number, only one or two being known in Asia, Africa, North and South America, and Australia. Leucite was unknown as a rock-forming constituent outside Europe until within a comparatively recent date. It has now been found to occur in North and South America, Africa, and Asia. In Asia, until the latest discovery of leucite in Australia, only two localities were known, Java, and the north-west of Persia. In 1885 Mr. David, while engaged in making a geological examination of the country between Bourke and Byrock, in connection with the prospects of obtaining artesian water in that district, discovered the hills of leucite-basalt, near Byrock.* Although this is the first recorded occurrence of leucite in Australia, as far as the authors are aware, it is due to the Rev. J. Milne Curran, F.G.S., to state that he knew of the existence of leucite-basalt at Byrock probably at an earlier date than that of Mr. David's first visit to the locality. The fact, therefore, is that the Rev. J. Milne Curran and Mr. David, working quite independently of one another, discovered the leucite-basalt almost simultaneously. At the end of 1887 the discovery of the El Capitan leucite rock was made conjointly by Mr. Anderson in company with the Rev. J. Milne Curran, F.G.S., then of Cobar.†

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* Mineralogical Magazine, London, 1887, pp. 193-194.
† See Curran, Proc. Linn. Soc. N. S. Wales, 1887, Vol. II., pp. 974-975.

II.—Localities and References.

The following is a list of the known localities of leucite-bearing rocks, together with such references as it was in our power to obtain :—

Localities.

EUROPE.—(1) Capo di Bove, near Rome. (2) Frascatinas, Rome. (3) Monte Somma, near Naples, in prehistoric lavas, earlier than the Plinian eruption of A.D. 79. (4) Vesuvius in lava and pumice from date of Plinian eruption to 1868. (5) Rieden, près du lac de Laach, Eifel. (6) Olbrück, lac de Laach, Eifel. (7) Bongsberg, near Pehn, Eifel. (8) Kaiserstuhl, Baden. (9) Saxony. (10) Bohemia. (11) Thuringer Wald. (12) Rhon Mountain. (13) Wester Wald. (14) Westphalia. (15) Vogelsgebirge. (16) Scania, S. Sweden. (17) Sardinia.

AMERICA.—(18) Pinhalzino, Poços de Caldas, Brazil. (19) Leucite Hills, Wyoming, U.S. North America.

AFRICA.—(20) Cape Verde Islands. (21) Mount Kilimanjaro, Masai Land.

ASIA.—(22) North West Persia. (23) Isle of Bawean, North of Java. (24) Byrock Mountain, near Bourke, N. S. Wales. (25) El Capitan, near Cobar, N. S. Wales.

References.

H. Rosenbusch : Microscopische Physiographie Wichtigen Mineralien (Stuttgart), 1873.

Dr. F. Zirkel : Die microscopische Beschaffenheit der mineralien and Gesteine (Leipzig), 1873.

(3) and (4), H. J. Johnston—Lavis : Quart. Journ., Geol. Soc., Vol. XL, pp. 35-119.

(4) Haughton and Hull : Transactions of the Royal Irish Academy, vol. XXVI, pp. 49-164.

(18) Professor O. A. Derby : Quart. Journ. Geol. Soc., vol. XLIII, pp. 457-473.

(19) Microscopical Petrography, U.S. Geological Exploration of 40th Parallel (1876), p. 259.

(21) Ueber die Gesteine des Kilimandscharo und dessen Ungebung-Tschermak's Mit. u. petro, g., Mitt. x 1888, p. 236. Hyland.

(23) Neues Jahrb. für Min. 1875, p. 175.

III.—Stratigraphy.

LEUCITE is known to occur in Australia as yet only in two isolated localities, some forty miles apart, on the borders of the Cretaceous plains of the interior of this Colony. One of these is Byrock Mountain, about six miles west of Byrock Township, which latter is situated on the western railway, about fifty miles south-easterly from Bourke, and four hundred and fifty miles north-west of Sydney. The other locality is known as El Capitan, situated in the western corner of the County of Canbelego, about forty miles south of Byrock Mountain. The leucite-basalt here forms a series of small hills with a few outlying hillocks some miles distant. A remarkable feature in connection with the occurrence of these leucite-basalts is the entire absence of any development of basaltic or other lava within a radius of at least one hundred miles of them, the nearest being the small outlier of Tertiary basalt of unknown composition, marked on the map as occurring in the basin of the Macquarie River.

The hills formed of the leucite-basalt present similar physical characters both at El Capitan and Byrock. Their summits and sides are bare of timber and they are

locally known as bald hills. When viewed from some distant eminence they are, therefore, conspicuous objects, standing out above the tree-clad plains. There is generally little depth of soil on them, and they usually present a rough, stony appearance from the great number of loose blocks which are strewn over their surfaces. None of them attain any great height above the surrounding plains.

Near Byrock there is one large hill known as Byrock Mountain, which rises about one hundred and thirty feet above the plains, and six hundred and eighty feet above sea level. It is about two miles in length by one in breadth, with three minor isolated rises to the west of it, distant less than two miles. On the largest hill the basalt is thickest at its western end, and gradually thins out towards the east. These are the undenuded remnants of a superficial lava-flow, but as far as our examination went, no evidences of the presence of a crater or orifice of eruption were visible in connection with them. Proofs are not wanting of the existence of old river gravels below the basalt at one point, near Byrock Mountain, and a rounded pebble of Palæozoic quartzite, two inches in diameter was found imbedded in the substance of the lava. About twenty miles to the south of Byrock Mountain, Silurian quartzites occupy a considerable area in the neighbourhood of Coronga Peak, a hill rising nearly one thousand feet above the plains, and it is probable that this pebble may have been derived from these quartzites, and if so, its inclusion in the leucite-basalt may indicate that the lava flowed from the southward. A microscopic examination of this pebble shows that it has been somewhat indurated externally by the lava. The presence of the pebbly drift below the basalt shows that the lava, after its eruption, flowed down an old watercourse, and a comparison of the level at which this drift occurs, with the present general level of the plains, favours the supposition that the eruption could not have taken place within recent times. From an examination of the neighbourhood of the mountain, it is probable that the basalt here rests wholly, or in part, upon granite, which has been intruded among the Silurian slates and quartzites of the district. Outcrops of this granite are seen on the plains to the south of Byrock Mountain, and at the Byrock Waterhole, near Byrock. In the immediate vicinity of the mountain the plains are covered with Pleistocene red soil of variable depth, which generally covers the outcrops of the Silurian slates and granite, as well as a large portion of the isolated basins of horizontally bedded Cretaceo-Tertiary strata, which rest upon and are partially surrounded by them. In this part of the district the aggregate superficial area occupied by the Cretaceo-Tertiary rocks is probably larger than that occupied by the outcrops of the older Palæozoic rocks.

The lava of the Byrock mountain is tolerably dense, even at its upper and under surfaces, and is not locally brecciated like that of El Capitan. A fragment of granite, much weathered, about six inches in diameter was picked up by one of the authors near the top of the mountain, considerably above the level of any of the neighbouring out-crops of granite. Unless this fragment was carried by human agency

to the position where it was found, which seems improbable, it was most likely derived from pre-existing hills of the same granite, which now forms the base of Byrock Mountain.

The hill known as El Capitan, is situated in the north-west corner of the County of Canbelego, and is distant thirty-five miles in a north-west direction from Cobar, and forty miles south of Byrock Mountain. The hills of leucite-basalt are here more numerous and of less individual extent, and more detached than is the case at Byrock Mountain. In fact, two or three isolated bald hills, doubtless consisting of leucite-basalt, could be seen some miles off to the south of El Capitan. In outline, the denuded remnants of this basaltic flow are very irregular, so that even an approximate estimate of their aggregate extent and area could not be ascertained, from the necessarily limited examination that could be made of them. Some portions of the rock are very fresh, while others are quite full of amygdaloidal cavities, some of which contain secondary products, and in such positions the individual minerals are much decomposed and altered. In one place the rock presents almost the aspect of a tuff, having a brecciated appearance, and being very full of secondary material. It rests here on the Silurian rocks of the district, which in some places are seen rising to considerable height above the lower levels of the basalt, and represent the sides of the old valley down which the lava flowed. There is also visible below the basalt a considerable amount of cemented river-drift. Thus we have in both localities at Byrock Mountain and El Capitan, evidence to show that the lava on its eruption flowed down an old drainage channel burying the creek bed with its drift below it, and therefore the eruption must have been subaerial.

IV.—Chemical Composition.

The following analyses of the leucite-basalts from Byrock and El Capitan respectively, have been made by Mr. J. C. H. Mingaye, F.C.S., &c., Analyst and Assayer to the Department of Mines :—

	Byrock. I.	El Capitan. II.
Silica	46·43	47·31
Alumina	15·99	18·51
Oxide of iron ($Fe_2 O_3$)	15·04	14·56
Lime (Ca. 0)	9·27	7·57
Magnesia (Mg. 0)	1·74	2·28
Potash (K_2 0)	6·93	6·14
Soda (Na_2 0)	·51	·98
Phosphoric Anhydride ($P_2 0_5$)	·73	·55
Moisture	3·20	2·31
	99·84	100·21
Sp. gravity of mineral	2·890	2·910

Mr. Mingaye states that both these samples were partly decomposed by hydrochloric acid with the separation of granular silica.

The most remarkable feature about these analyses is the small proportion of magnesia as compared with the abundance of olivine revealed by the microscope.

Estimated by means of drawing the outlines of the olivine, as seen under the microscope, on paper with the aid of a Wollaston's prism, and cutting out and weighing the circumscribed portions of the paper, and reducing the proportions by bulk so arrived at to proportions by weight, the amount of olivine in 100 parts of the leucite basalt was found to be the following:—

In No. 49*a* Byrock, olivine	11·1
In No. 53 ,, ,,	11·3
In No. 59*a* El Capitan, olivine	4·5
In No. 61*a* ,, ,,	6·7

The above results are obviously only approximate. According to the chemical analyses above quoted the amount of magnesia present in the case of the Byrock lava would produce only 3·4 per cent. of olivine, on the assumption of a composition for olivine of 50·90 of magnesia in 100 parts of olivine, and in the case of the El Capitan lava 4·48 of olivine. It would appear, therefore, especially in the case of the Byrock lava, that, even supposing the whole of the magnesia to have been absorbed by the olivines, without, that is, allowing any for the pyroxenes, or mica, there is not sufficient magnesia in the rock to produce the amount of olivine actually present, if the latter were a typical magnesian olivine. Microscopic examination, however, shows that the olivines of the Byrock Mountain are of somewhat unusual appearance, showing well-marked parallel fibrous lines having unusually sharp crystal faces, and being of a yellowish-gray to reddish-brown colour. These olivines are also fringed with the deep reddish brown mineral, evidently of secondary origin, and formed from a combination of part of the constituents of the olivine with the iron of the base of the leucite-basalt. In optical character this mineral somewhat resembles melilite, and is partly soluble in cold hydrochloric acid.

The Byrock olivine may therefore be poor in magnesia, but correspondly rich in lime, and may be a calcareous variety allied to monticellite or leucophanite. A great number, however, of determinations will have to be made by means of the microscope in the manner above described to ascertain the actual average proportion of olivine present, before any positive assertion can be made with regard to the relation of the olivine to the magnesia present in the rock.

Estimated by the same method the minimum amount of leucite present in slide No. 49*a* was 37·5 per cent. by bulk, and 25 per cent. by weight. This result, however is probably below the true quantity, as no account was taken of the very numerous minute leucites, too small to draw.

Assuming that all the potash, given in the analyses, was absorbed by the leucites, there is sufficient potash in the Byrock lava to produce 32·2 per cent. of leucite, and in the El Capitan lava to produce 28·6 per cent.

In the case of slide No. 54*a*, Byrock, the cover glass having been removed and the balsam washed off with spirit, the leucites were treated with cold hydrochloric acid, and the effect watched under the microscope with a ¼-inch objective. It was observed that the surfaces of the leucite rapidly became eroded into a system of anastomosing tubular hollows, similar to those observable in the natural rock in slide No. 50*a* and figured on Plate XXVIII, Fig. 2.

The melilite-like secondary mineral in the same slide, treated in like manner became partially dissolved a trifle more rapidly than the leucite.

The small proportion of soda in the rock, as shown by the analyses, precludes the possibility of nepheline being present, at all events to any appreciable extent, and it may be attributable to analcime and nosean, both of which are probably present. The phosphoric anhydride in the rock confirms the surmise, based on microscopic examination, as to the identity of many of the small prisms, hexagonal in cross-section, with apatite, a fact to which Professor Judd* has already called attention. This is the first record of the occurrence of phosphoric acid in any appreciable quantity in a rock-mass in New South Wales.

V.—Macroscopic Character.

In colour the Byrock rock is bluish-black with innumerable brownish coloured glistening plates of mica scattered through it. In texture it is compact and fine grained and sometimes has a distinctly lamellar structure. Its specific gravity is 2·890. The mica and the olivine are the only porphyritic minerals that are discernible with the naked eye. On weathered surfaces the rock appears rough from the unequal weathering of the various minerals. When struck with the hammer it rings sharply like a phonolite.

The El Capitan rock is more variable in texture and structure than the Byrock. In colour it is lighter being of a dirty grey. Its specific gravity is 2·910. In texture it is usually compact, but in places it is scoriaceous. In at least one locality, however, a considerable thickness of the lower surface of the flow is scoriaceous, and has now become amygdaloidal from the deposition of secondary material in the steam cavities of the scoriæ. The scoriaceous character of the lava at this point has no doubt been due to the fact that it here flowed into the creek or river which occupied the bed of the valley down which the lava flowed. It also presents a brecciated character which gives it the appearance of a tuff, but this is confined to restricted areas.

* *Mineralogical Magazine*, 1887, p. 194.

VI.—Microscopic Characters.

(a) General.

In general microscopical characters the rock presents a finely crystalline structure, having some of the contained minerals developed micro-porphyritically, some of them, especially the olivines, being even macroscopic. This structure is so well marked that it is justifiable to describe the rock as consisting of a base, in which are imbedded the larger micro-porphyritic crystals. The base consists of a micro-crystalline aggregate of *leucite, augite,* and *magnetite* in varying proportions, with occasionally a little glassy material. The minerals which occur micro-porphyritically throughout the base are *leucite, olivine, mica,* and *nosean* (?). The base varies considerably in comparative quantity in different parts of the rock. In some places it is very abundant, and in others very scanty, where the bulk of the rock is made up of the micro-porphyritic leucite, olivine, and mica the individual micro-porphyritic crystals being separated only by a single layer of augite prisms and magnetite. It consists chiefly of minute leucites, augites, and magnetite with a little glass. The general arrangement of the lath-shaped augite crystals, in the base, is often such that their longer axes are parallel to one another, thus indicating flowage structure. The general texture of the base varies greatly, in some instances being so coarsely crystalline that the structure is almost doleritic, whilst in others it is quite aphanitic. Aggregations of some of the minerals of the base frequently occur forming irregular masses, sometimes surrounded by a border of leucite. Augite and leucite, to the exclusion of the other minerals, are often observable aggregated together. Sometimes the magnetite alone of the base minerals is absent, and often minute fragments of mica enter into the composition of these aggregations—olivine very rarely. Glass is also present in some instances.

Leucite occurs in the rock in great abundance, both in the form of minute, more or less circular crystals in the base, and also micro-porphyritically, but it never attains a macroscopic size. It is generally roughly crystalline in outline, which, however, is usually obscure, and is more rudely circular than polygonal. It is developed generally in individual crystals, which are each surrounded by base, but frequently a series of individuals are grouped circularly around a nucleus which may consist of magnetite alone, or a minute portion of the crystalline base, or of glassy material. It often forms a boundary to the crystalline aggregates formed of the other minerals of the base. The crystals rarely show, under crossed nicols the twin lamellation so characteristic of the large leucites of Somma and Vesuvius, except in a few cases, where it is faintly distinguishable. Inclusions are common, and chiefly consist of crystalline augite, apatite, and magnetite, with many minute circular and oval bodies, which may be glassy beads. Minute pale brownish coloured crystals, generally in hexagonal sections, occur in some of the leucites, and these are very probably noseans. The crystalline inclusions are generally arranged indiscriminately

through the leucite crystals, but sometimes they are radially or concentrically arranged. The glass inclusions are generally arranged in a concentric manner. In a few instances the leucite presents a distinctly zonal structure, each octagonal zone being marked out by minutely beaded lines which may be formed of granules of magnetite or glass (?). Very often the centre of the crystal is occupied by a minute black speck, which is probably a crystal or group of granules of magnetite. Such leucite crystals present the appearance as if they had crystallized around the nucleus as a centre. Some of the leucites, particularly in slides Nos. 50*a* and *b*, present a somewhat curious structure. In many cases nearly the whole section of the crystal is seen to consist of a network of anastomosing tubuli, which occupy considerable areas and bands traversing the crystal. This structure can only be distinctly seen under a high power, and it seems to occur chiefly in leucites in which there are few or no microlithes of augite and apatite, although it also occurs where those are present. In some cases this network can be demonstrated to be only an apparent one, due to the superposition of microliths of apatite (?) which do not lie in the same vertical plane, and whose entire outlines can be seen crossing each other according as each individual is brought into focus. In other cases, however, the tubuli can be seen to be bent, and to present a wavy outline which is certainly not a crystalline outline. From the fact that in section this anastomosing network is usually observed to occupy more or less narrow bands crossing the leucite crystal, it is probable that they have been developed not indiscriminately through the crystal, but, as a rule, along certain planes. It is suggested that this structure may be due to corrosion which acted perhaps along the solution, or possibly the stress planes of the crystal. This structure, as already mentioned, can be imitated experimentally by washing with cold hydrochloric acid, the surface of leucite crystals in microscopic slides, which do not naturally show this structure. Leucite occurs commonly included in the plates of mica, and sometimes it forms more or less amorphous masses, where the individuals are not crystalline, but are irregularly matted together so as, in section, to have the appearance of a mosaic. In some places the rock is so rich in leucite that the base is hardly apparent, but this is very local.

Augite occurs as one of the chief constituents of the base in the form of small lath-shaped crystals, and it is also frequently present in a micro-porphyritic form. It has the yellowish-green tinge characteristic of augite. It often shows twinning and its microliths are about the most common occurring in the leucites. It was probably one of the earliest minerals to crystallize out. Magnetite is a very common inclusion in the augite, and very often the micro-porphyritic augites have a distinctly crystalline outline. It is one of the commonest minerals found in the aggregations. In a few instances the micro-porphyritic augites show a uralitic cleavage. (No. 54*a*).

Magnetite, as a rule, occurs plentifully in the base, generally in the form of individual cubical crystals, but sometimes also in small aggregates. It is also found included in the leucite in minute grains, which often occupy the centre of the crystal, and in most of the other minerals.

Olivine occurs chiefly as a micro-porphyritic form, and very rarely (if ever) as a constituent of the base. It is generally indistinctly crystalline in outline. Of all the minerals it is the one which most frequently shows decomposition. It sometimes takes the form of geniculate twins, and as a rule the crystalline form is generally rounded off, the outline being well marked by a boundary of magnetite. Many crystals are quite fresh and undecomposed, and all gradations can be seen from wholly fresh crystals to crystals which are entirely occupied by decomposition products. The decomposition which the olivine has undergone is somewhat peculiar and unusual. It has not taken place, as is usually the case from the periphery of the crystal inwards along the cracks, but it seems to have progressed from the periphery along lines which lie very close together and are at right angles to the long axis of the crystal, although in some cases the cracks where present also show slight decomposition. The decomposition product is in part serpentinous and in the earlier stages is yellowish-green, but the ultimate alteration is into a reddish-brown mineral which is either allied to a ferriferous mica or to melilite, more probably the latter from the fact that it never shows pleochroism. When this decomposition has only partially taken place it gives the crystal a perfectly fibrous structure. A somewhat similar fibrous decomposition of the olivine has been observed in a dolerite containing porphyritic mica from a small basalt flow in the breach of the crater of an extinct volcano called "The Gap" in the Parish of Lorne, County Gough, Vegetable Creek District, N. S. Wales.

Mica is present generally in the form of macroscopic flakes, and also in small microscopic individuals. They rarely or never have a crystalline outline but are large irregular ragged looking masses. In colour it varies much from deep orange brown to pale yellow. The basal cleavage is strongly marked. Mica often enters into the composition of the aggregations in the form of minute irregularly shaped pieces. The larger flakes are indented by, and include, individuals of all the other minerals, leucite, augite, magnetite and even olivine, but nosean has not been observed in them as an inclusion. Mica must therefore have been the last of all the minerals to crystallize out and has the appearance of having filled up all the irregular spaces which were left by the crystallization of the other minerals.

Apatite occurs only as clear transparent lath-shaped microliths which are very commonly included in the leucite crystals in great numbers. It does not occur in the base.

Nosean (?).—The mineral which has provisionally been identified as nosean occurs as macroscopically porphyritic crystals of rare occurrence, and also as minute well-formed six-sided crystals included in the leucites. In the case of the large porphyritic crystals the mineral has undergone considerable decomposition, being altered probably into analcime. They present a corroded appearance with no evidence of their original crystalline outline. The minute forms included in the leucite are of a pale brownish colour and are perfectly crystalline.

(*b*) *Description of Slides.*

No. 49*a*, from Byrock Mountain. A micro-crystalline rock, composed chiefly of crystals of leucite, with smaller crystals of augite, chiefly prismatic, and still smaller crystals of magnetite. Olivine occurs in granules, often aggregated in groups of two or three, and sometimes large enough to make the rock micro-porphyritic. It is always more or less decomposed, and exhibits a fibrous structure *due to serpentinisation.* Micro-porphyritic plates of yellowish mica occur somewhat plentifully, enclosing crystals of augite and leucite in such a manner as to present the appearance of its having taken the place of the augite and magnetite which occur interstitially between the grains of leucite in the rest of the slide. This mica is strongly pleochroic, and exhibits strong basal cleavage. A well-marked geode $\frac{1}{3}$ of an inch in diameter occurs at the margin of the slide, composed chiefly of mica, which in polarised light is seen to be composed of large crystals, but in ordinary light shows only a mosaic of mica, with a few smaller crystals of the same mineral. Intermixed with the mosaic mica in the geode are aggregated crystals of magnetic iron, many of which are invested with a thin coating of leucite. The geode, where it joins the general rock, is partly surrounded by a zone of intercrystallized leucite and magnetic iron with a little augite and mica.

No. 49*b*, from Byrock Mountain. Good inclusions in leucite. Olivine decomposed bottle green to reddish brown. In one part of slide the leucite occurs in an aggregated mass of partially individualized crystals surrounding an oval nucleus of some singly-refracting mineral (leucite or glassy base ?).

No. 49*c*, from Byrock Mountain. An isolated patch of glass surrounded by leucite occurs in this slide.

No. 50*a*, from Byrock Mountain. Leucites perforated by irregular-shaped branching tubuli, apparently produced by corrosion (Pl. XXVIII, fig 2). Edges of all the leucites much corroded. Several crystals of triclinic felspar present, also much corroded. A little mica chiefly found investing the leucites.

No. 50*b*, from Byrock Mountain. A few amygdules consisting of a white partially-opaque secondary mineral, showing plumose structure partly isotropic and partly anisotropic. These have somewhat the appearance of corroded porphyritic decomposed crystals of nosean.

No. 51, from Byrock Mountain. Leucite in well-shaped crystals. Prismatic augite, with abundant magnetite. Olivine in micro-porphyritic grains, remarkably free from decomposition. One aggregation of magnetite surrounded with leucite, with polarising minerals in the centre, perhaps prismatic needles of augite (probably the whole may be a large decomposed nosean or colourless hauyne). Small porphyritic flakes of mica, of an amber-yellow, or deep sherry-brown, under single nicol.

No. 52*a*, from Byrock Mountain (Pl. XXVIII, fig. 6). Remarkable fibrous mineral of rusty brown colour present. A decomposed variety of olivine (Pl. XXVIII, fig. 5). A few micro-porphyritic crystals of triclinic felspar also present. Magnetite abundant. Some of the leucite crystals contain spherical inclusions of a nearly colourless faint brownish isotropic material, which may be beads of glass. Natrolite (?) present. In some cases the olivine grains present the appearance of geniculate twinning (Pl. XXVIII, fig. 5).

No. 52*b*, from Byrock Mountain. The olivine is aggregated into clumps, and some individuals show unaltered centres, but with the fibrous decomposition penetrating them. The augite is chiefly in the form of lath-shaped micro-porphyritic crystals, many of them twinned. Some leucites have included crystals very minute, generally giving hexagonal sections and isotropic. They are mostly of a pale purplish-brown colour with a darker interior surrounded by a narrow clear exterior, and are probably nosean. Inclusions of a pale yellowish-grey prismatic augite also occur in the leucite, and long slender prisms of a colourless mineral with tranverse cracks, which is probably apatite.

No. 53, from Byrock Mountain. The olivine here shows partial decomposition, in many cases the centres of the crystals being quite fresh. Some of the leucites are arranged in aggregations either circularly around a nucleus, which consists almost entirely of a portion of the base more finely crystalline than the surrounding base, and containing a little glass (?), or in globular masses of aggregated crystals finely crystalline towards the centre and more coarsely crystalline towards the periphery, which consist wholly of leucite, and a little isotropic material, which may be glass, is present in the central portion of the aggregation.

No. 54*a*, from Byrock Mountain. This section shows perhaps better than any other what may be termed the base, consisting of minute crystals of augite, magnetite and leucite in which the micro-porphyritic minerals are imbedded. The olivines are very remarkable. They are much decomposed towards the centres, where they exhibit a fibrous structure, but towards the edges they have been altered into a translucent reddish-brown or sherry-red mineral, which has a fibrous structure more strongly marked than that of the partially decomposed portions of the olivine. They are very feebly pleochroic. This mineral, which is certainly an alteration product from the olivine, may be a ferriferous variety of melilite or possibly a

ferriferous magnesian mica. The feeble pleochroism, however, of the mineral renders the former supposition the more probable. It is partially soluble in cold hydrochloric acid. Some of the micro-porphyritic augites in this slide exhibit a uralitic cleavage.

No. 54*b*, from Byrock Mountain. Similar to preceding slide. The olivines are much decomposed and converted at the edges into the deep brown mineral. Some of the individual leucite crystals enclose a nucleus of partly devitrified glassy base, the diameter of the nucleus being half the whole diameter of the crystal. In some cases these nuclei are composed of bundles of glassy beads. In other cases the glassy nuclei are surrounded by contiguous leucite crystals. Augite occurs in the form of slender prisms of a pale yellowish-grey colour in the base and also in micro-porphyritic prisms. The decomposed olivines edged with the reddish-brown decomposition mineral are frequently encircled with a fringe of primary mica. In cases the olivine is completely changed into this reddish-brown mineral, which shows a strong cleavage and is encircled by the fringe of primary yellow mica, the strong pleochroism of the latter is in marked contrast to the feeble pleochroism of the former. Glass occurs occasionally in the base in small irregular shaped pieces with dusty magnetite distributed through it.

No. 54*c*, from Byrock Mountain. Numerous micro-porphyritic crystals of olivine present, many of them remarkably fresh, without a sign of the yellowish-brown decomposition product, although they are usually cracked transversely to their longer axis. The larger fresh-looking forms have well defined more or less rectangular outlines, while those which show the fibrous brownish decomposition are irregularly oval. One triangular aggregation of the base is seen in section to consist almost entirely of minute irregular fragments of leucite and mica. Two sides of the triangular outline of this mass are defined by wavy lines of small leucite crystals. Augite is present in micro-porphyritic crystals. Another aggregation occurs, consisting almost wholly of minute crystals of olivine, with a little leucite.

No. 55, from Byrock Mountain. Slide shows general similarity to the two preceding, and contains a small undevitrified fragment of glass, about half an inch in diameter, with dusty magnetite sprinkled through it. Very remarkable instance here of a leucite crystal formed around a nucleus of fine magnetite and mica. This may be an explanation of the intercrystallized leucite and magnetite in other slides. There is also a similar arrangement of augite crystals around an included portion which is formed of the other minerals. Some augites show twinning, and sometimes the inclusions in the crystals have a somewhat zonal arrangement.

No. 56, from Byrock Mountain. Micro-porphyritic crystals of undecomposed olivine in elongated prisms with irregular edges. Augite occurs in very much elongated prisms yellowish-grey. A small cavity is observable, partly filled with minute crystals of magnetite, and enveloped by a thin coating of finely crystalline leucite. The olivine shows fibrous outlines of decomposition extending at right angles to the

domes and pinacoids. Leucite shows faintly polarising lines, and in places occurs enclosed in the flakes of mica. A small amygdule (?) is observable of yellowish-grey mineral, slightly cloudy.

No. 57, from Byrock Mountain. Spherical amygdule or segregation of glassy material, or very finely crystalline leucite, with magnetite and mica encircled by a ring of leucite in partly individualized crystals. Some olivines much decomposed, others fairly clear.

No. 58, from Byrock Mountain. Two well-marked hollow (?) aggregations of leucite, enclosing a little magnetite and mica. The leucite occurs in the form of a ring, fairly thick, and is in partly individualized crystals. Very characteristic of this slide are aggregations of partly individualized crystals of leucite, arranged in a circular manner around portions of the base, sometimes composed of finely crystalline magnetite and mica, and sometimes of what appears to be partly divitrified glassy base. (Pl. XXVIII, fig. 4). One leucite crystal shows very clearly concentric lines of growth. (Pl. XXVIII, fig. 2). Minute crystals of nosean (?) occur enclosed in some of the leucites. Perhaps some elæolite or natrolite in this slide—possibly analcime. Glass inclusions in the leucite. (Pl. XXVIII, fig. 2).

No. 59*a*, from position (*a*), El Capitan. There are slight differences between this rock and the Byrock in its general microscopical characteristics. It consists of a micro-crystalline base of finely crystalline leucite, augite, and magnetic iron, with abundant macroscopic grains of undecomposed olivine, and small flakes of yellowish mica, the latter chiefly encrusting the granules of olivine. Magnetite, besides occurring in small crystals in the base, forms aggregated micro-porphyritic patches, some of which have a dendritic structure. In a small geode augite occurs in pale yellowish gray micro-porphyritic crystals, associated with olivine and magnetite, and a little leucite. In the base there is a considerable amount of cloudy interstitial material, due perhaps to the imperfect separation of the magnetite or to the decomposition of ilmenite. The aggregates of magnetite or ilmenite are surrounded by leucites in a finely crystalline state. In some of the aggregates an opaque dirty white or reddish-grey mineral occurs which is probably a decomposition product. The appearance of a cavity in the leucite aggregates seems to be due in one case here to the mechanical grinding away of the nucleus of magnetite. Fragments of crystals of triclinic felspar showing polysynthetic twinning occur very sparingly and amorphous leucite in places intercrystallized with the magnetite. Lines of flowage are noticeable in base.

No. 59*b*, from position (*a*), El Capitan. A porphyritic compound crystal of augite ¼ of an inch in diameter, very much corroded. Porphyritic granules of olivine are abundant and very free from decomposition. (Pl. XXVIII, fig. 3.) The aggregates of iron are also macroscopic. The porphyritic grains of olivine show lines of solution (?) or basal cleavage. Base shows flowage structure.

No. 59*c*, from position (*a*), El Capitan. Remarkable oval aggregate of magnetite and leucite intercrystallised in a similar manner to the intercrystallization of quartz and felspar in pegmatite. This is suggestive of the segregative origin of the leucite aggregations. The prismatic crystals of augite in the base in their arrangement show strong lines of flowage. A few micro-porphyritic crystals of augite occur.

No. 60*a*, from position (*b*), El Capitan. Rich in macroscopic strongly pleochroic yellow mica. Secondary mineral resembling deep reddish-brown mica, or melilite pseudomorphous after olivine. Small zeolitic (?) bodies of a clear white mineral, which is partly isotropic and partly feebly anisotropic, are perhaps analcime.

No. 60*b*, from position (*b*), El Capitan. Large zeolite of a fibrous, cloudy, yellowish-grey, doubly refracting mineral, perhaps natrolite or wollastonite, surrounded by a narrow zone of a well-crystallized clear, transparent mineral almost isotropic in part. Abundant prismatic augite here in the base, which is composed of felted augite, leucite, and magnetite, all more coarsely crystalline than in the previous slides. Olivines show decidedly fibrous structure and alteration into secondary dark brown mica or melilite.

No. 60*c*, from position (*b*), El Capitan. Lines of flowage strongly marked. The chief feature in this slide is a large individual of olivine much decomposed into a yellowish-brown, somewhat opaque, brittle mineral surrounded by a zone $\frac{1}{8}$ inch thick of olivine, leucite, and augite more finely crystalline than the general rock, and characterized by the absence of magnetite. The zone merges gradually at its outer edge into the typical rock, but there is a sharp line of demarcation between its inner edge and what may be an inner narrow zone of secondary aragonite, which occurs as an alteration product having a fibrous radial structure in or around the decomposed olivine. Imperfect prisms of a mineral varying in colour from yellow, through green, into blue, is observable in association with the decomposed olivine in this inner zone, and is apparently a decomposition product, perhaps aragonite.

No. 60*d*, from position (*b*), El Capitan, consists of a micro-crystalline base of felted crystals of augite with small leucites and magnetite, with olivine tolerably abundant in slightly micro-porphyritic crystals much decomposed. Brownish-yellow mica occurs micro-porphyritically in flakes quite free from decomposition. Augite also occurs in twinned micro-porphyritic crystals the ends of which are rounded off or corroded. Oblong or oval patches of leucite (?) are observable in aggregation with the flakes of mica. Fragments of augite prisms are included in this aggregate of leucite. The ends and edges of these included augites are studded with minute granular bodies showing a tendency to a fibrous radial arrangement, and perhaps of the same composition as the augite. The phenomenon may be due to the partial dissolving of the augite prisms and the recrystallization of the dissolved mineral upon the augite. In the neighbourhood of these aggregates are crystals resembling

garnets in colour. Examined, however, under the highest power, they are seen to be composite bodies composed of a clear white mineral incrusted by somewhat opaque brownish granular matter, similar to that noticed on the augite prisms. These may therefore be leucites coated with granular augitic (?) matter.

No. 60*e*, from position (*b*), El Capitan. In this section the base is somewhat similar to that in the preceding one, but enclosed in it is an oval macroscopic body composed of a yellowish-grey, somewhat opaque mineral enclosing isolated portions of the base. This body is about ½ inch long, by ⅓ inch wide, and the mineral of which it is composed shows a decidedly parallel fibrous structure in places, and under-crossed nicols allows only a little light to pass, which shows that it is made up of small mosaics similar to those observable in amygdaloidal minerals. Before the blow-pipe the mineral reacts strongly for soda and fuses to a clear glass without intumescence. Hardness between 5 and 6. It is regularly attacked by hydrochlorid acid. It is therefore a silicate of soda, &c., and as it is of secondary origin, as proved by its mosaic structure it is probably analcime. The fact, however, of portions of the base having been included in it renders it improbable that the whole body is an ordinary amygdaloid. It seems more probable that it is a large pseudomorph after some soda-bearing silicate such as nosean. It is certainly to be referred to the same mineral as was observed in Slide 50*b*, which is nearly isotropic and shows well marked cleavages, as already described. It is just possible, however, that this soda silicate may be pseudomorphous after olivine.

No. 61*a*, from position (*d*), El Capitan, consists of a micro-crystalline base of felted augite, leucite and magnetite, with micro-porphyritic olivine crystals very free from decomposition, micro-porphyritic flakes of yellow mica and one large microscopic augite very much corroded. The leucites are characterized by circularly arranged inclusions of glassy beads.

No. 61*b*, from position (*d*), El Capitan. The base is similar to the preceding, but contains secondary growths of fibrous aragonite in places. This slide is very rich in leucite and contains an oval aggregate of decomposed leucite and interstitial aragonite. Most of the decomposed leucite in this aggregate shows the distinct outlines of the original crystals and the characteristic zonal inclusions, but is of a yellowish-grey colour, a trifle opaque, and somewhat resembles the large opaque bodies which occur in Slides 60*e*, and 50*b*, and which it was suggested might possibly be decomposed nosean.

No. 62*a*, from position (*c*), El Capitan. Macroscopically this section presents a somewhat brecciated appearance, which however, on microscopical examination is found to be due more to the presence of irregular aggregations and the non-uniform distribution of the magnetite, than to a true fragmental structure of the rock, although there are a few bodies present which may have been introduced prior to its

thorough crystallization. The slide is characterized by the presence of abundant micro-porphyritic crystals of olivine, whose outlines are much corroded, and which are imbedded in a finely crystalline base, consisting of minute crystals of augite, leucite, magnetite and mica. The olivines are as a rule fresh, but show distinct serpentinisation along the cracks and often around the outlines, the product being a bluish-green clear mineral, which is isotropic. The whole rock is very much more finely crystalline and more compact than any of those previously described. The bodies which may have been introduced subsequent to the eruption, but previous to the final consolidation of the lava present an irregular outline and are generally slightly elongated and angular. They consist of a blackish nearly opaque and somewhat streaky base of very fine magnetite and probably glassy material enclosing small irregular crystals of leucite. Fragments of more coarsely crystalline leucites occur in the finely crystalline base, but viewed under the microscope, the edges of these fragments merge gradually into the more finely crystalline base, so as to give them the appearance of being comparatively coarsely crystalline aggregates. Probably both the fragments, which have the appearance of having been introduced subsequent to the eruption of the lava and the more coarsely crystalline aggregates, which form an essential part of the base, have been formed from the partially cooled and solidified portions of the lava, derived probably from its upper or under surface, which has become broken up from time to time by the movements of the lava-stream, and entangled in the magma at its under surface. It is also possible that some of these fragments may have been originally lapilli, although their irregular outline and restricted occurrence (these fragments being found only in the under part of the lava-sheet within a few feet of its lower surface) are rather opposed to this theory. The specimens, from which these slides were prepared, were taken from within a few feet of the under surface of the lava-sheet at El Capitan. Had these tuffs been derived from a point of eruption, beds of them would probably be observable interstratified with the lava-sheet, and such have not yet been observed. The surface also of the lava-flow would probably in that case have partaken of a tuffaceous nature which it does not.

No. 62*b*, from position (*c*), El Capitan. This slide closely resembles the last in general appearance and microscopical characters, except that here the fragmental appearance is not so well marked.

No. 62*c*, from position (*c*), El Capitan. Generally similar in structure to the last two—showing two kinds of fragments, and one variety of aggregate.

No. 63*a*, from position (*e*), El Capitan. This slide presents a much more brecciated appearance than those last described. Many of the fragments have a distinctly defined outline, and most of them are darker from the greater abundance of magnetite, than the rest of the rock. The whole section contains a large number of micro-porphyritic much decomposed olivines. These occur scattered through the rock, and

are of frequent occurrence in many of the fragments, which also contain recognizable leucites, thus showing indisputably that some of these are really fragments of the earlier consolidated portions of the lava, which have been broken up by the movements of the flow. Numbers of the fragments however, do not contain micro-porphyritic olivines nor recognizable leucites, but generally show an indistinctly laminated structure. These are undoubtedly foreign fragments, probably small pieces of the slate rock over which the lava flowed, and which were picked up by it. A few fragments of elongated shape, irregular outlines, and extinguishing completely under crossed nicols are probably glass. These are opaque towards the centre and clear at the edges. The longer axes of these fragments generally lie approximately parallel to one another, and probably "end on" to the current of the lava-stream. They are imbedded in a tolerably clear base containing numerous small flakes of mica, and prisms of augite, and dotted with minute magnetite crystals. This base under crossed nicols is seen to be largely composed of doubly refracting minerals.

No. 63*b*, from position (*e*), El Capitan. Besides having a brecciated appearance, this section shows abundant amygdaloids. Fragments are observable, both of leucite basalt and of slate (?), in a base consisting of magnetite, augite, and leucite; the first mineral being by far the most abundant, and in which are imbedded micro-porphyritic crystals of much decomposed olivine and flakes of mica. The amygdaloidal cavities are generally small but very numerous. They are of two kinds, the first irregular shaped, and the second having a circular or roughly hexagonal outline. Both are partially or wholly filled with a turbid grey mineral, with a faint reddish tinge. In cavities of the first kind the mineral has a strongly marked fibrous structure, the fibres having their longer axes at right angles to the sides of the cavity. In amygdaloids of the second kind, the mineral appears to be pseudomorphous after leucite, and has probably resulted from the decomposition of that mineral. In both kinds the mineral is probably analcime.

No. 63*c*, from position (*e*), El Capitan. This section presents macroscopically a minutely brecciated appearance. (Pl. XXVIII, fig. 1.) The majority of the fragments are seen microscopically to be undoubtedly pieces of the leucite basalt, showing individually great differences in constitution. Some consist almost entirely of magnetite, with a few crystals of leucite, and others have the general character of the typical rock. The whole section is very dark, almost opaque, from the enormous quantity of magnetite present, but the fragments are, as a rule, the darkest. Scattered indiscriminately through the section, in most of the fragments as well as in the general base, are large micro-porphyritic crystals of decomposed olivine, showing the usual fibrous decomposition. Some fragments are present which show an indistinctly laminated appearance, and these are probably pieces of slate which

have been caught up by the lava as it flowed over the surface. It is also probable that there is a considerable amount of glassy material in the base, which consists chiefly of leucite, augite, magnetite, and minute fragments of mica, and from the great abundance of magnetite it has quite a granular appearance.

VII.—Comparison with other Leucite-bearing Rocks.

There is a very marked similarity between the Byrock and El Capitan rocks, both macroscopically and microscopically. Some slight differences exist between them, which do not, however, weigh much against the probability of their having formed portions of the same eruption. The El Capitan rock is somewhat lighter coloured, but in part more decomposed, not so uniformly compact, and has the porphyritic minerals olivine and mica better developed than is the case in the Byrock rock. The rocks are otherwise identical both in chemical composition and mineralogical constitution. So far there is little evidence as to the direction in which the lava flowed, for no traces of a crater or other point of eruption have yet been met with in any part of the district. In general appearance the Australian leucite basalt resembles very much the leucitite of the Capo di Bove, near Rome. In microscopical structure it differs somewhat from it, chiefly in the abundance of its olivine and mica, and the absence of primary melilite and nepheline. In the comparative abundance and distribution of the leucite, augite, and magnetite, the two rocks are very much alike. The chemical analyses of the Byrock and El Capitan leucites, combined with approximate estimates made from drawings from the microscopical sections of the rock, show that the Australian leucite basalts contain nearly the same proportion of leucite as the Vesuvian lavas, erupted between 1631 and 1868, described by Haughton and Hull (*loc. cit.*), the percentage of leucite in the latter ranging from 33·6 to 44·9 per cent., calculated on the hypothesis of a minimum amount of paste. The minimum proportion of leucite in the Australian lencite basalts is 25 per cent., and it probably amounts to about 30 per cent. in places.

VIII.—Age.

The evidences as to the age of the eruption of this lava are not so far of a conclusive character. The question whether these widely separated outliers of basalt originally formed portions of one lava-flow remains yet unsettled, although from their similarity of composition and microscopic structure, it is probable that they did so.

That they may be of Palæozoic age is unlikly from the comparatively small amount of decomposition which the component minerals of the rock have undergone, although from their stratigraphical position they may have existed as outliers since Palæozoic times, like the neighbouring horizontally-bedded Devonian outliers which rest unconformably on the upturned edges of the Silurian slates, and form

Mount Oxley. The leucite basalts could not, however, have been older than the Devonian, for pebbles of Silurian quartzite occur in the basalt at Byrock Mountain.

During Secondary times this part of the country must have been more or less under water, and it is evident, from the general character of the leucite rock, and the occurrence of water-worn river-drift underneath it, that the lava must have originally flowed out over dry land. There is every reason for believing that, during the earlier part of the Secondary Period when the Lower Cretaceous formation was being deposited over the central part of the continent, this district, situated near the edge of the Cretaceous sea was, if not wholly under water, at any rate in the condition of an archipelago. It is even probable that during the deposition of the Upper Cretaceous, or Desert Sandstone, this district was still locally submerged, and if the lava had been erupted during Secondary times when such physical conditions obtained, some portions at least of the basalt would undoubtedly present subaqueous characters. This is, however, not the case except locally, where the scoriaceous character of the rock is quite satisfactorily explained by the fact that at such points the lava flowed into the waters of the creek, which existed in the bed of the valley down which the lava flowed.

So far as we know, there is no stratigraphical evidence to show that the rock had a Post-Secondary origin, although it is not unlikely that such was the case, and that it was erupted in early Tertiary (?) times, like the Eocene basalts of New England in this Colony. The point of eruption of this lava was probably no exception to the general rule, in being situated near the sea. In the Byrock and El Capitan districts the latest known marine formation is of Cretaceous age. It is possible, however, that in these districts outliers may yet be found of the marine Miocene formation, which occupies so large an area of the south-west of the Colony. The date of the eruption of the leucite basalt, therefore, probably lies somewhere between the Lower Cretaceous and the Miocene periods. Of all the various outliers in the two localities none of them, so far as were examined, rested upon the Cretaceous formation. Their nearest points, some forty miles apart, are separated by a stretch of level country from which rise high isolated hills formed of Silurian quartzite, the denuded peaks of Pre-Secondary mountains, but, so far as it has been traversed and examined, with no outliers of leucite basalt.

There is abundant evidence to prove that the degradation which this country has undergone since early Tertiary times has been very great and it is not improbable that those portions of the flow between El Capitan and Byrock Mountain may have been completely denuded; because most of the level country between those two points consists of the more or less soft beds of the Cretaceo-Tertiary formations, and if the lava had covered these in a continuous flow it would have been far more liable to be denuded off such easily eroded strata than from a position where it rested on

the hard Silurian slates or granite, for, as already stated, such portions of it which still exist rest, in the one case on Silurian slate and in the other on granite, so that in those positions its denudation would not be assisted by the fact that the underlying rocks were soft and therefore easily worn away. There is, however, a tract of country between Coronga Peak and the Western Railway, which has not yet been thoroughly examined, so that it is just possible that other outliers of the rock may yet be discovered which will perhaps show a probable continuity between these two places. If these numerous outliers are the remnants of a single lava-flow, it is impossible that its eruption could have taken place within recent times, because of the enormous denudation they have undergone. If this fact be taken into account together with the comparatively small amount of decomposition which the individual minerals have undergone, and the absence from this district of marine conditions, which are usually a necessary element in the volcanic eruptions, during, at the latest Post-Miocene times, it seems very likely that its eruption took place during Cretaceous or Tertiary times, and when the various outliers have been more thoroughly examined this may possibly be proved, by stratigraphical evidence especially by the discovery of plant remains in the river drifts under the basalt, similar to those found in the pipeclays and lignites of the Tertiary "deep leads" of the Cordillera of New South Wales.

XVIII.—Our Present Knowledge of the Palæontology of New Guinea: by R. ETHERIDGE, Junr., Palæontologist.

[Plate XXIX.]

SO LITTLE is at present known of the Palæontology of New Guinea that it may perhaps be well to pass in review the different, although brief papers, relating to the subject, and to add what little information can be gathered from more recently made collections.

So far as I am aware, no fossils of Palæozoic, and only those of Mesozoic age to the least possible extent have been noticed from New Guinea, and the existence of fossiliferous Tertiary rocks was, I believe, first announced by Mr. C S. Wilkinson, who based his determination on a small series of specimens obtained at Yule Island, during the progress of the "Chevert" Expedition, under Sir W. Macleay. During this exploration were obtained, amongst other rocks :—

(1.) Oolitic limestone of Tertiary age from Bramble Bay.

(2.) Yellow calcareous clay, from the Katau River.

(2.) Yellow and blue calcareous clays, from Yule Island, and Hall's Sound.

The clays from the last named localities were believed by Mr. Wilkinson, "as indicated by the fossils contained in them, to belong to the Lower Miocene Tertiary period,*" and to be similar to like beds at Geelong, and Cape Otway, in Victoria.

From Hall's Sound, Mr. Wilkinson determined *Voluta macroptera*, M'Coy, *V. anticingulata*, M'Coy, and a number of other shells only named generically, and therefore of little use from any but a general stratigraphical point of view. The Katau and Bramble deposits were believed to be of the same age. The Yule Island rock is wholly composed of corals, shells, and echini, forming a "concrete of fossils." This paper was followed by two from the pen of the Rev. J. E. T. Woods,† entitled "On a Tertiary Formation at New Guinea ‡," and "On some Tertiary Fossils from New Guinea"§. Both these memoirs deal with the same fossiliferous deposit at Yule Island, which Mr. Wilkinson had before him. They are evidently intended as a refutation of the conclusions arrived at by the latter; but strange to say, no mention whatever is made of Mr. Wilkinson having previously occupied himself with the subject. The first paper contains a description of an Echinid, *Temnechinus Macleayana*, Ten.-Woods, and records as fossil the occurrence of a known living species, viz., *Peronella decagonalis*, Lesson. *Temnechinus* is a European and Indian Tertiary genus, and lives still, although, as Mr. Woods says, is chiefly indicative of a Pliocene age. *Peronella decagonalis* is a recent species, met with in eastern seas. The conclusion arrived at by the author is that the deposits yielding the fossils in question, are not as old as the Murray River, Mount Gambier, or Cape Otway Tertiaries, but he regards them as Lower Pliocene.

In the second paper, two shells are described, *Pecten novæguineæ*, and *Dolium costatum*. These are held to confirm the previously expressed views, and Mr. Woods was of opinion that none of the New Guinea fossils were identical with those of Southern Australia. No mention whatever is made of the two univalves, *Voluta macroptera*, and *V. anticingulata*, specially referred to by Mr. Wilkinson.

So far as I have been able to gather, the first reference to fossils of Secondary age from New Guinea occurs in Mr. C. S. Wilkinson's Annual Report on the Geological Survey of N. S. Wales for 1877‖, wherein he states that the collection of M. d'Albertis contained Ammonites. In an anonymous article in the Sydney *Daily Telegraph*¶, Mr. Wilkinson is credited with assigning these Ammonites to the Upper Oolite or Lower Cretaceous. It is thus quite clear that about this time Secondary rocks had been recognized, support being given to this by some remarks made by Professor F. W. Hutton, in his excellent essay on the "Origin

* Proc. Linn. Soc., N. S. Wales, 1876, I. pt. 2, p. 113.
† Since these remarks were written Natural History has lost one of its most devoted followers by the death of the Very Rev. J. E. Tenison-Woods, which lately took place after long and painful suffering.
‡ *Ibid*, 1877, ii, pt. 2, p. 125.
§ *Ibid*, pt. 3, p. 267.
‖ Ann. Report, Dept. Mines, N. S. Wales, for 1877, [1878], p. 199.
¶ Jan. 5th, 1886.

of the Fauna and Flora of New Zealand"*. Therein he says :—"Of the geology of New Guinea it is known that Jurassic rocks are largely developed both in the north and in the south . . . . . no Cretaceous rocks are known from any part."

The next publication bearing on the Palæontology of New Guinea was a paper by the late M. de Miklouho-Maclay,† who described a large part of the coast thereabouts as nothing more than uplifted coral-reefs, but from a greenish sandy clay, forming the nearest hills to the coast-line at the village of Bongu, from 100 to 400 feet high, he collected thirty-eight species of mollusca. From the determinations of Mr. J. Brazier,‡ who examined the collection, it is manifest that this deposit can only be regarded as of Post-Tertiary age. The species are identical with those now living in Torres Straits, the China sea, and around the Philippine Islands. The following is a list of those specifically determinable taken from Mr. Brazier's paper :—

Ranella albivaricosa, *Reeve.*
Nassa siquijarensis, *A. Adams.*
Oliva neostina, *Duclos.*
 „ lepida, *Duclos.*
 „ ispidula, *Linn.*
Terebra staminea, *Gray.*
Dendroconus glaucus, *Linn.*
Strombus canarium, *Linn.*
Bullá ampulla, *Linn.*
Atys cylindrica, *A. Adams.*
Dentalium longitrorsum, *Reeve.*
Corbula crassa, *Hinds.*
Corbula albuginosa, *Hinds.*
Tellinella M'Andrewi, *Sby.*
Arcopagia pinguis, *Hanley.*
Phylloda foliacea, *Linn.*
Tellinides conspicua, *Hanley.*
Peronæa scalpellum, *Hanley.*
Metis spectabilis, *Hanley.*
Chione calophylla, *Hanley.*
 „ imbricata, *Sby.*
Dione bullata, *Sby.*
Leda pullata, *Hinds.*

To within a few months ago this included all that was known to the writer of the Palæontology of New Guinea. Both the Germans and Dutch§ may have obtained collections from their respective portions of the island; but, if such is the case, the descriptions have not come under notice.

During the comparatively recent expedition to New Guinea in 1885, fitted out by the Royal Geographical Society of Australasia,‖ a few fossils were obtained which next claim our attention. From the head of the Strickland River an olive-green mudstone was obtained, full of comminuted marine fossils, chiefly mollusca. The lithological character of the matrix points to a volcanic origin. None of the species were nameable.

From the first foot-hills of the Upper Strickland River a block of fine sandstone, containing *Pecten*, was obtained. This, Mr. A. J. Vogan, who was attached to the

* Presidential Address to the Philosophical Institute of Canterbury, N. Z., Nov. 1st, 1888.
† Volcanic Activity on the Islands near the north-east coast of New Guinea, &c. *Proc. Linn. Soc. N. S. Wales*, 1885, ix., pt. 4, p. 963.
‡ *Ibid*, p. 988.
§ Prof. K. Martin, of Leiden University, has published a paper entitled "Eine Tertiarformation von Neu-Guinea und benachbarten Inseln" (*Samml. Geol. Reichs-Mus. Leiden*, 1881, I., pp. 65–83, t. 3), in which a Tertiary species of *Alveolina* is described. A general geological summary regarding New Guinea is also given.
‖ Special Record of the Arrangements for the Exploration of New Guinea. *Proc. Geograph. Soc., Australasia Special vol.*, 1885, p. 157.

expedition, informed me was *in situ*. The shells are too much worn by weathering to attempt a specific determination, but they seem to have more of a Tertiary than a Secondary aspect.

At Observatory Bend, Strickland River, numerous travelled nodules and small boulders were collected, revealing a totally different kind of life, chiefly the remains of Ammonites. But amongst them is a bivalve, either an *Aucella* or an *Inoceramus*. If the latter, it is decidedly of the type of the Cretaceous, *I. concentricus*. Unfortunately the characters of the hinge cannot be ascertained. These fossils are, however, of little importance when compared with the Ammonites. Out of a number of nodules, in which the fossils are indicated by impressions of casts, a fairly representative series has been selected, containing four more or less recognizable species, or at any rate species which can be referred to one or other of the sections into which the old genus *Ammonites* is now broken up, and the facies of which is sufficiently clear for broad generalization.

The section *Stephanoceras* is largely represented by an Ammonite of the group of *A. calloviensis*, Sby. (Pl. XXIX, fig. 5), and even closely allied to that species. At first sight the primary costæ springing from the umbilical margin are not very apparent in our specimens, but attentive examination reveals them as in D'Orbigny's figure* of this species, but closer together, and therefore more numerous. It would also appear that the umbilicus is smaller than in the European form, and less telescopic, wherein these shells approach *Stephanoceras transiens*, Waagen,† from Kutch, or *S. maya*, J. de C. Sby.‡ They possess the same form and arrangement of ribs as in the latter, which commence quite simple at the umbilicus, and break up at about equal distances into bundles of three, whilst the shell is rather more compressed.

The next species partakes of the form of *Stephanoceras Blagdeni*, J. Sby. (Pl. XXIX, fig. 2), or equally well with *S. coronatus*, Brug. It is a small shell, with the costæ of the back and the tubercles less marked than in the above species. On the other hand the cross-section of the whorls clearly indicates its relation to this group. The specimen also partakes, in some degree, of the features of the shell figured by D'Orbigny as *Ammonites Humphresianus*,§ but the umbilicus in the former is deeper. A comparison may also be made with Quenstedt's figure of *S. coronatus*.‖

Two rather well marked Ammonites (Pl. XXIX, figs. 1 and 3) appertain to the group of *Stephanoceras lamellosum*, J. de C. Sowerby,¶ but as compared with that species, possess a wider and more open umbilicus, with the costæ of the back less

* Pal. Franç. Terr. Jur., Ceph. I. Atlas, t. 162, f. 10.
† Pal. Indica, Jurassic Fauna of Kutch, I. Ceph. t. 32, f. 2a.
‡ Trans. Geol. Soc., V (2) t. 61, f. 8.
§ Pal. Franç. Ter. Jur., Ceph. I. Atlas, t. 134.
‖ Cephalopoden, 1849, Atlas t. 14, f. 4a.
¶ Trans. Geol. Soc., V (2) t. 23, f. 8.

upwardly curved and more horizontal; in fact the costæ are all more direct and lack the sigmoidal curve on the flanks of *S. lamellosus.* From *S. Grantianum*, Oppel, as figured by Waagen, the costæ seem to be finer, but to J. de C. Sowerby's figure of this species, under the name of *A. Herveyi,** our fossils bear a close resemblance, and also to D'Orbigny's figure† of the same, in the breadth and nature of the back. An affinity is also to be detected with the same author's *Ammonites macrocephalus,*‡ but not with that of Waagen, under the same name. A third fragment, however, possesses costæ quite as coarse as those shown in the latter's illustration of *Stephanoceras Grantianum.*

Yet another Ammonite (Pl. XXIX, fig. 4), which Dr. H. Woodward, who was kind enough to examine casts of all these fossils sent to him by myself,—compares to *A. lingulatus,* Quenst., of the White Jura. Figures of this species are not accessible to me, and I cannot find anything precisely like it, although it seems to be of the Upper Oolite type of *A. Lamberti,* Sby., and *A. Sutherlandiæ,* Sby., as figured by D'Orbigny,§ in so far as the break in the double costation goes, but the back of our shell is much too broad, and the costæ too fine. The square back, with its oblique costæ, and the marginal crenulations, all convey to this shell a much more Upper Oolite or Lower Cretaceous aspect than they give to it a Lower Oolite facies. Neither is it impossible that a relation may exist between it and *A. Leai,* Forbes.||

So far as our present knowledge of Queensland Ammonites exists there is no connection between the latter and either of the species described above, although our Pl. XXIX, figs. 1 and 3, bear some resemblance to Moore's *Ammonites macrocephalus*¶ from Western Australia.

The only other organic remains so far brought from New Guinea, were obtained by Mr. Theodore Bevan during his fifth and last exploring expedition along the south coast of the island in 1888.** These consisted of a few shells from the Aird Hills, Douglas River, and were determined by Mr. J. Brazier, and the writer. They were obtained from an earthy-mould, or silty-mud, and cannot be geologically of any great age, but are of considerable interest from the position of the deposit containing them. This is described by Mr. Bevan in the following words:—"The term Aird Hills describes an island of probably moderately recent upheaval, on which a cluster of volcanic cones, some ten in number, and covering an area of about five square miles, are surrounded by deep navigable channels of fresh water . . . The general formation of these trachyte hills is a volcanic tuff. The summit of

* Trans. Geol. Soc., V (2) t. 23, f. 5.
† Pal. Franç. Ter. Jur. Ceph. I. Atlas t. 150.
‡ Pal. Franç. Ter. Jur. Ceph. I. Atlas, t. 151.
§ Pal. Franç. Terr. Jur. Ceph. I., Atlas, t. 177.
|| Quart. Journ. Geol. Soc. I. p. 178, t. 12, *a* and *b*.
¶ *Ibid*, xxvi. t. 15, *f*. 5.
** Mr. Theodore F. Bevan's fifth expedition to British New Guinea, 1888, p. 21 (8vo. Sydney, Government Printer).

this particular cone, however, is covered with a deposit of semi-fossilized fluviatile shells contained in an earthy mould or silty-mud." The species determined were the following:—

Melania clavus, Lamarck.—This species is represented by several examples. It is found in the living state at New Ireland and at the Philippines; it was also obtained by Mr. John Brazier, in the Solomon Islands.

Neritina gagates, Lamarck,—comprises more than two-thirds the entire collection, and is present in several varieties. It is a characteristic New Guinea species, and was found by Mr. Brazier in the Katau River.

Cyrena sp.—Several valves, which cannot exactly be referred to any known species from New Guinea. They approach nearest to *Cyrena nitida*, Deshayes, from Borneo, and are, perhaps, only a variety of it.

The collection of the Queensland Geological Survey has been enriched by the presentation by Mr. E. Edelfelt of specimens of brown or yellow marl from Maiva Village, found at a height of about two hundred feet above sea level. The marl has plentifully scattered through it the remains of small shells in the form of internal casts, and a few fragmentary corals. By the kind permission of my co-writer, Mr. R. L. Jack, the following extract from our forthcoming work on the "Geology and Palæontology of Queensland," may be appropriately inserted here:—

The most striking of the corals is a species of *Alveopora*, allied to those described by Dr. A. E. Reuss, from the Tertiary beds of the Tiji-Lanang Valley, Rongga District, Java.* The trabecular septa are strong and spine-like, much curved, and six, or perhaps more, in a cycle. They have this peculiarity, that they appear to be developed in pairs, a character to some extent seen in Reuss' specimens, but in the present fossils carried to a much higher degree. The spurious columella formed by the union of the septa is of the slightest construction. In the character of the septa this coral appears to be most nearly allied to *Alveopora brevispina*, Reuss,† but in other features to *A. hystrix*, Reuss.‡ If the paired condition of the septa, here so very marked, is a constant and definite character, and it appears to be so, it will at once distinguish this coral from all those described by Dr. Reuss.

The largest and best preserved coral is a species of *Leptoria*, a genus not met with either by Reuss, amongst the Javan corals, nor by Professor K. von Fritsch,‖ amongst those collected in Borneo by Mr. R. D. M. Verbeek. On the other hand Professor K. Martin, of Leyden,§ describes an allied genus *Cœloria*, from the former country. The characters of the New Guinea *Leptoria*, as portrayed in the single specimen are not sufficiently clear for specific description, and make one long for further materials. *Leptoria* is extensively distributed in the Indian and Pacific Oceans.

Next in order is a well-marked *Galaxea*, again only a fragment, but clearly not far removed from the recent *G. clavus*. The corallum, as preserved, is split in half longitudinally, and exhibits several corallites radiating outwards, surrounded by a copious peritheca.

* Uber fossile Korallen von der Insel Java. *Reise Osterr. Fregatte "Novarra,"* 1851-59. *Geol. Theil*, II *Band*, 2 *Abth.*, p. 165.
† *Loc. cit.*, t. 3, f. 7, *a–e*.
‡ *Ibid*, t. 3, f. 8, *a–c*
‖ Fossile Korallen der Nummulitenschichten von Borneo. *Palaeontographica*, 1878, *Suppl. Band* III., *lief.* 1, *heft* 3, p. 93.
§ Die Tertiärschichten auf Java, 2 Theil, p. 137 (folio, Leiden, 1880.)

The last to be noted, but certainly not the least important, are two examples, fragmentary unfortunately, of the interesting genus *Deltocyathus*, distinct both from the Tertiary and recent species *D. italicus*, Ed. and H., and the recent *D. magnificus*, Moseley. The occurrence of this genus in these New Guinea beds is of the highest interest, following as it does upon its discovery by the "Challenger" Expedition in the Pacific.*

The material presented by Mr. Edelfeldt to the Queensland Survey Collection is of too limited a nature to permit any definite statement to be made as to the age of the beds, but they are either younger Miocene or Pliocene, probably the latter. The Javan series described by both Reuss and himself are considered by Professor K. Martin to be of Miocene age."†

Such is a brief outline of the Palæontology of New Guinea, so far as it is known to the writer. Briefly reviewing these facts, it is manifest that the oldest fossiliferous rocks on this island-continent, of which we at present have any record, probably correspond homotaxically with the Upper Oolites of other countries, more particularly the European, at the same time displaying some relation to the Indian beds of the same age. As regards the *Inoceramus* it would appear to resemble an old-world Cretaceous species; but the specimen being a single one too much stress must not be laid upon this point. It may simply be said that Cretaceous rocks put in a claim for consideration.

Of the Tertiary fossils it is necessary to speak more fully, but with caution. The presence of *Voluta macroptera* and *V. anticingulata* in the Yule Island deposit, would go a long way towards correlating the latter with the beds containing these shells at Schnapper Point and Muddy Creek, in Victoria, as suggested by Mr. C. S. Wilkinson. I am indebted to the kindness of Prof. W. T. Stephens, M.A., for an opportunity of examining the Yule Island collection in the Macleay Museum, ‡ but the species mentioned were not observed there, and only those described by the Rev. Mr. Woods came under observation. An attentive examination of these rather leads me to accept Mr. Woods' suggestions as to the age of the fossils in question. The matrix is also clearly the same as that containing the corals collected by Mr. Edelfelt at Maiva Village. §

The urchin described as *Temnechinus* does not appear to belong to that genus as defined by its originator, Edward Forbes, ‖ and at the present moment I am not prepared to generically place the specimen. It may probably be an undescribed form.

The *Peronella* would appear to be a small individual of the characteristic and generally distributed Australian species, to which Mr. Woods has referred it. The specimen of *Dolium costatum*, although only an internal cast, is one of so strongly

* "Report on certain Hydroid, Alcyonarian and Madreporarian Corals," &c., by Prof. Moseley—*Voy.* "*Challenger.*" *Zoology*, *vol.* II., 1881, p.p. 147 and 148.

† *Loc. cit.*, 2 Theil, p. 38.

‡ The fossils were collected by Mr. Brazier.

§ Specimens are in the Mining and Geological Museum, as well as in the Queensland Survey collection.

‖ Mon. Echinodermata Brit. Tertiaries, 1852, p. 5. The New Guinea fossil does not possess the typical excavations along the sutural margins of the plates seen in all true forms of *Temnechinus*, nor are the ambulacral plates confluent. These characters are emphasized by Forbes, and accepted by A. Agassiz in his Revision.

and distinctly marked a species as to be readily recognizable from the other Australasian forms. The simple and distant costæ and canaliculate suture distinguish it at once. The *Pecten novæ-guineæ* is not identical, says Mr. Brazier, with any existing species in neighbouring waters, and must therefore be regarded, with the so-called *Temnechinus*, as peculiar to the Yule Island deposit. It is, however, remarkably like a South American *Pecten*, described by D'Orbigny from the Tertiary rocks of Patagonia, as *P. paranensis*. * In addition to the species just mentioned, I detected in one of the blocks of the Macleay collection the internal cast of a *Strombus*, which Mr. Brazier regards as that of *S.* (*Gallinula*) *Campbelli*, Gray, a species now living in the Australian seas.

XIX.—On the Mineral Spring at Rock Flat Creek, near Cooma, Monara District: by WILLIAM ANDERSON, Geological Surveyor.

[Plate XXX.]

THIS spring is situated about ten miles to the south-east of Cooma, and occurs in close proximity to the western bank of Rock Flat Creek, in the Parish of Dangelong, County of Beresford.

Since the early days of the settlement of this part of the Colony, it has been known as the "Soda-water Spring," and used to be a favourite camping ground for teamsters and travellers, who were attracted thereto by the reputed quality of the water. It has been largely used by the people living in its immediate neighbourhood, and the spring has at the present time become a favourite resort by the inhabitants of the district.

From report it would seem that years ago its volume was much greater than it is at present. This may, to a certain extent, be due to the long continued droughts, which have been of late years so prevalent in this Colony. Though such droughts can hardly affect the supply of water from a deep-seated spring to such an extent as they would that from a more superficial one, yet they must have a secondary effect in lessening the amount of water that finds its way to the surface, for the want of surface soakage allows of the superficial strata becoming more or less dessicated, and this necessitates a wider soakage of the spring-water among the

* See Darwin's Geol. Obs. Volc. Islands and Pts. of S. America, Voy. "Beagle," 2nd. Edit., 1876, t. 3, f. 30. In *P. paranensis* each costa, as in the New Guinea species, is divided into three or four ribs. The concentric laminæ in the latter are continuous over the costæ and intervening valleys, forming frills, but in the former the ribs of the costæ are separately decorated by concentric lines of projecting tooth-like spines. The interior ear also in the South American form is more deeply divided than in our species, and the posterior is less granulate.

strata through which it rises during its passage from a deep-seated origin to the surface, and consequently the amount which reaches the surface must be appreciably diminished.

Large areas of the Cooma district are covered superficially with Tertiary basalt, which locally overlies pipeclays and river drifts. Generally these newer rocks rest on the Siluro-Devonian slates, with granite and other eruptive rocks intruded among them. Between Cooma and the spring at Rock Flat Creek, the country consists of Tertiary basalt, the whole thickness of which has been completely eroded in the vicinity of the creek, the Siluro-Devonian slates below it being thereby exposed at intervals in the bottom of the valley. In the neighbourhood of the spring the basalt terminates some distance to the east of the creek by abutting against the Siluro-Devonian hills, which still rise to a considerable height above its level, thus indicating that the country immediately to the east of the creek must have been at the time of the eruption of these Tertiary lavas high ground, formed of Palæozoic rocks. The valley which has been eroded by the creek is wide, open, and of considerable depth. In its neighbourhood and on the basaltic country generally there is little or no timber, the only positions in which a few dwarfed trees grow being on the outcrops of the Palæozoic rocks. In the bottom of the valley there are two outcrops of Siluro-Devonian quartzite, one close to the spring, and the other some distance up its western slope. On this latter outcrop although consisting merely of a mass of quartzite blocks with little or no soil among them, a few stunted trees grow. The trend of these quartzite outcrops shows the general strike of the Palæozoic rocks to be nearly north and south.

The spring rises in close relation to the western edge of the most easterly quartzite outcrop, but so little of the older Palæozoic rocks have been exposed that it cannot be visibly demonstrated that a fault exists along the line from which the waters emanate. It is however certain that it is in no way connected with the Tertiary lavas, that is to say that the spring is not a drainage coming from below the basalt, but it has probably a deep seated origin. From the occurrence of the two parallel outcrops of similar quartzite, and the presence of the spring in connection with one of them it is reasonable to infer, that they have been originally portions of the same bed and have become separated by the intervention of a fault, and that the deep seated waters have found their way to the surface by means of it. The faulting of the Palæozoic rocks is certainly much older than the eruption of the Tertiary basalt, but it is not probable that the waters of the spring came to the surface before the Tertiary lavas covered it, for there is no evidence of the existence of any previously formed calcareous tufa below the basalt, where a section can be seen in the neighbourhood of the spring, and all the calcareous accumulation now visible has certainly been deposited since the erosion of the valley, which has taken place since late Tertiary times.

The geology of the immediate vicinity of the spring is shown on Pl. XXX. In this locality the creek has cut through the Tertiary basalt and for a short distance into the Siluro-Devonian bed-rock which is exposed on the eastern bank, as a series of small quartzite ridges. The banks of the creek are formed of Pleistocene and recent alluvial flats of variable lateral extent. Between the quartzite ridges and the creek there is a superficial deposit consisting chiefly of carbonate of lime, which has been deposited by the overflow waters from the spring as they found their way towards the creek. This deposit occupies an area of about five acres, and at its northern end the waters of the creek have cut a passage through it, leaving on the western bank a small outlier of the deposit. Little or none of this calcareous tufa exists on the eastern side of this quartzite outcrop. The surface of the deposit is very uniform in appearance, that is to say, there is no well-marked arrangement of the superficial layers, simulating terraces, &c., which are often an accompaniment of such precipitations, although the northern end of the deposit, when viewed from a little distance, presents a faintly terraced appearance, which is, however, by no means marked.

The waters have, at various periods, flowed out at the surface by different openings, along the western edge of the more easterly quartzite outcrop. The position of these openings has changed progressively from south to north, the direction of the fall of the creek, the older ones having been at the southern end of the calcareous deposit, the chief opening now being near the northern. There are at present three small orifices from which the water flows. Two of these are, however very small and from them the flow is hardly appreciable. The third the most northerly, is the largest and from it the water flows freely in quantities sufficient to be utilized. This orifice is in the form of a small basin a few feet in diameter and in this the gases, chiefly carbonic acid gas, keep constantly bubbling up through the water. The basin always remains full and from it there is a constant overflow which passes over the surface of the calcareous deposit and so into the creek. There is no ferruginous deposition nor coating from the waters which flow from this orifice but from the small one at the southern end a decided ochreous looking film coats the sides and bottom of the small runlet which carries off the overflow. The creek is perennial and the overflow water from the spring which finds its way into it is so diluted by the waters of the creek that, below the spring, the slightly distinctive taste and qualities of the spring water are entirely lost.

The water as it issues from the spring appears somewhat milky from the quantity of minute bubbles of carbonic acid gas rising through it. The ebullition caused by the larger bubbles gives it an appearance as if it were boiling. It is slightly tepid, when the hand is introduced into it, its temperature being a little above the average summer heat.

It will be seen from the comparison of the analyses given below that in general chemical constitution this spring water approximates in the comparative abundance of the principal salts to the water from the Saratoga Seltzer Spring, New York State, United States. It is, however, not a saline water, like the latter, the bulk of the soda being in the form of a carbonate. It is a carbonated water, but there is not sufficient iron present to make it chalybeate. It is too hard to be potable. There is nothing disagreeable in its taste nor smell, in fact it tastes like ordinary soda water. So far as it has been tested it contains no albuminoid nor ammonia. No deleterious effect follows even a free use of this water.

	Saratoga Seltzer Springs. *		Soda Water, Cooma. †		Ballimore Springs. ‡
	grs. per gallon.		grs. per gallon.		grs. per gallon.
Carborate of Iron	1·70	....	1·40	Iron	0·70
Bicarbonate of Calcium.........	89·87	Calcium...............	40·10	Calcium...	......
Phospha'o ,, ...	trace		......		11·38
Fluoride ,, ...	trace		......		......
Bicarbonate of Sodium	29·43	Sodium	42·95	Sodium ...	183 10
Phosphate ,, ...	trace		......		......
Biborate ,, ...	trace		......		......
Chloride ,, ...	134·29		3·98		6·92
Iodide ,, ...	0·03		......		......
Bromide ,, ...	0·63		......		......
Bicarbonate of Magnesium ...	40·34	....	22·35	....	9·36
Sulphate of Potassium	0·56	Carb. of Potassium	3·50	Potassium	12·83
Chloride ,, ...	1·34		......		......
Bicarbonate of Lithium	0·90	....	0·21	Lithium ...	0·05
Bicarbonate of Strontium......	trace	....	......	Strontium...	trace
Bicarbonate of Barium	trace	....	......	....	......
Silica	2·56	....	1·03	....	0·28
Alumina	0·37	....	......	....	trace
Boracic Acid	trace	....	......	....	......
Organic matter	trace	....	13·40	....	......
	302·02		128·92		224·62
Carbonic Acid.....................	324·08	... .	24·81		

Ballimore water also contains free ammonia ...... 0·052 parts per 100,000 parts.
and albuminoid ammonia .... 0·003 ,, ,, ,,

An analysis of the mineral water from near Ballimore Hill, to the east of Dubbo, is given for comparison with the Cooma water. It is not, however, a natural spring, but an artesian supply which was tapped while boring for coal. It rises from a depth of over 500 feet from among a series of horizontally bedded sandstones and shales, which form a partially isolated basin, the Talbragar River Coalfield, belonging to the Carboniferous system. The supply from this source is very copious, and far exceeds that from the Rock Flat spring, but from its chemical composition the latter is better adapted for commercial uses.

* Bulletin of United States Geological Survey, No. 32, p. 40.
† Ann. Report Dept. Mines, N. S. Wales, for 1879 [1880], p. 48.
‡ Ann. Report Dept. Mines, N. S. Wales, for 1887 [1888], p. 47.

Two other analyses of the Rock Flat spring water are given below, but in these the relative quantities of individual salts have not been tested for :—

	Gr. per gallon.	Gr. per gallon.
Total solids	134·02*	133·98†
Soluble solids	59·96	62·77
Insoluble solids	74·06	71·21
Chlorine	29·51	14·78
Equivalents in Na. Cl.	48·60	24·35

The insoluble solids consist of carbonate and sulphate of lime, silica, and carbonate of iron. The soluble solids consist chiefly of chloride and carbonate of soda.

Waters containing abnormal quantities of various chemical salts, thus constituting mineral waters, are known to occur in different parts of the country, but so far none of them have ever been utilized commercially nor even to any extent as public resorts. The value of these waters for either purpose depends chiefly upon the presence of certain chemical salts which possess certain therapeutic actions, and the absence of others which have a deleterious effect upon the human system. Of the medical value of our mineral waters we know as yet little or nothing, and there certainly a wide field for research open to specialists in materia medica who are disposed to investigate the medicinal properties and therapeutic actions of the mineral waters of this country.

There is no reason why, as an industry, the preparation of such of our mineral waters as will advantageously lend themselves to the process, may not in course of time be a large and important one, and as public resorts, many of these springs cannot fail to become both commercially and medicinally of great public value and utility. Mr. Isaac Millner, of Sydney, has, I believe, within the last few months had the chief orifice of the Rock Flat spring cleaned out and slabbed down to the silurian bed-rock, to facilitate the collection of the water prior to its preparation for use at a distance. It is to be hoped that this venture will prove to be the initial step towards the extensive development of the commercial and medicinal uses of the mineral waters of this Colony.

* Ann. Report Dept. Mines, N. S. Wales, for 1885 [1886], p. 41.
† Ann. Report Dept. Mines, N. S. Wales, for 1885 [1886], p. 42.

PLATE I.

Fig. 1. Longitudinal section of cliff at Long Bay, showing the Hawkesbury
Post Tertiary strata at the point where the Human Remains
found.

Fig. 2. Vertical or cross section of the same.

Fig. 3. The Skeleton lying in the position in which it was found, with the im
ments and shells *in situ*.

Fig. 4. The larger of the two skinning knives; side view.

Fig. 5. Cross section of Fig. 4.

Fig. 6. The smaller of the two implements; side view.

Fig. 7. Cross section of Fig. 6.

Figs. 1, 2, and 3 are on a scale of eight feet to one inch.

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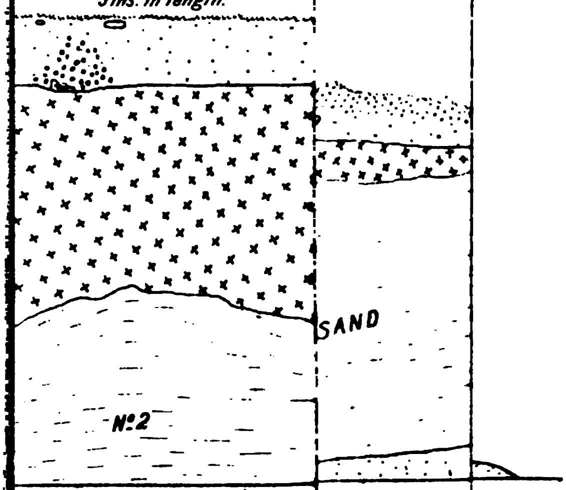
REMAINS

LONG



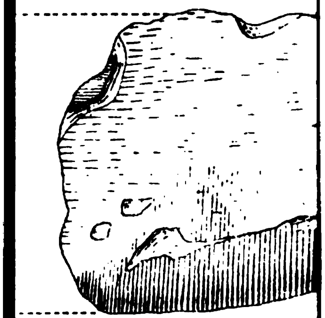


Fig. 4

PLATE II.

Geological Sketch-Map of Sunny Corner, county of Roxburgh, by Mr. Wilkinson, Geological Surveyor-in-Charge, and Mr. W. And Geological Surveyor. Scale—forty chains to one inch. [Extr from the *Ann. Report Dept. Mines, N. S. Wales, for* 1886 [1 *App. E.*]

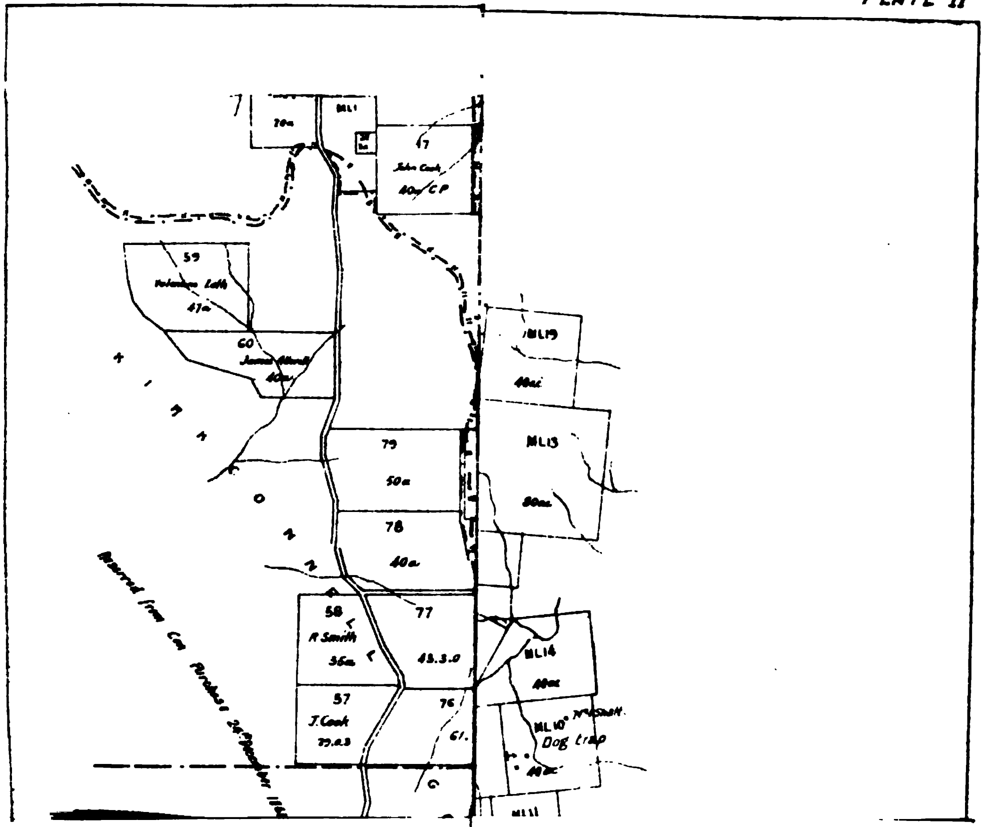

20a
ML1
17
John Cook
40a C.P
59
47a
60
40a
ML19
40a
79
50a
ML13
80a
78
40a
58
R. Smith
56a
77
43.3.0
ML14
40a
57
J. Cook
76
61
ML10
Dog trap
40a

PLATE II*a*.

Fig. 1. Quartz-porphyry from M.L. 11, Parish of Castleton (slide No. 8), showing secondary quartz filling a cavity in the base whose outline assumes a botryoidal form, from which numerous fibrous radiations pass into the quartz.

Fig. 2. Sphærulitic quartz-porphyry from M.L. 88, Parish of Castleton (slide No. 11*b*), showing a sphærulite in polarised light.

Fig. 3. Quartz-porphyry from Great Mitchell Extended Mine, Parish of Castleton (slide No. 12*b*), showing fluxion structure.

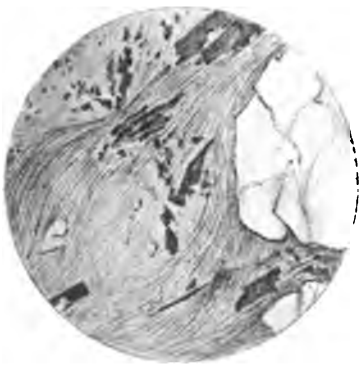
Fig. 4. Quartz-porphyry from Tonkin Mine, Parish of Castleton (slide No. 15*b*), showing a corroded porphyritic quartz.

Fig. 5. Non-porphyritic felsite from No. 2 level, Sunny Corner Mine, Parish of Castleton (slide No. 18*c*), showing the mode of occurrence of iron pyrites in the non-porphyritic felsites.

Fig. 6. Sphærulitic quartz-porphyry from M.L. 88, Parish of Castleton (slide No. 11*a*), showing the porphyritic ingredients, quartz and felspar, and epidote in the base.

1

2



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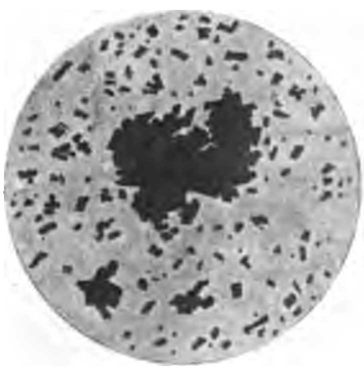
4



5

6

11a 234—88

√ PLATE III.

Lonsdaleia? bipartita, *sp. nov.*

Fig. 1. Portion of the corallum, seen from above, showing the deep calices, vesicular zone, septa, &c. x 1½.

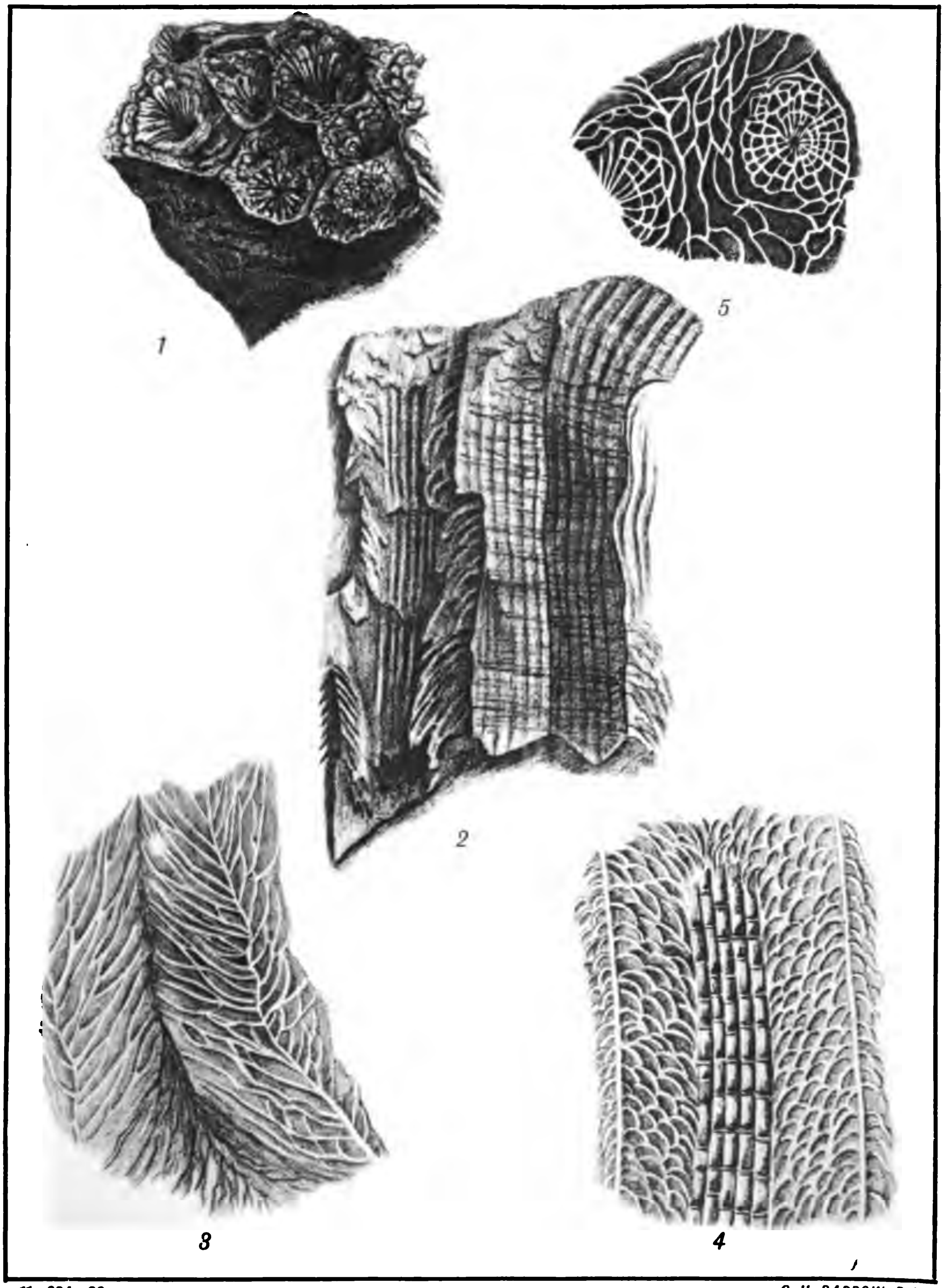
Fig. 2. Longitudinal view of three corallites, those on the right showing the external appearance, and that on the left in section, with the septa and vesicular plates visible. x 1½.

Fig. 3. Vertical section of a corallite prepared for the microscope, showing the boundary walls and vesicles. x 3.
(N.B.—This section has been inadvertently turned upside-down.)

Fig. 4. Vertical section of another corallite from a polished hand specimen, showing the boundary walls of the corallites, the vesicular zone on each side, and the central septal area with the broken vertical lamellæ, and the small horizontal tabulæ. x 1½.

Fig. 5. Horizontal section prepared for the microscope with two corallites, showing the large vesicles of the outer area and the septa of the inner zone which do not meet in the centre. x 3.

11*a* 234—88



11a 234—88

G. H. BARROW, Del.

PLATE IV.

Sketch of the Horton River Falls, near Messrs. Sawers and Wilson's Lindsay Station, showing basaltic columns forming the bank and bed of the stream: by Mr. H. W. Powell, Forest Ranger.

Plate IV.

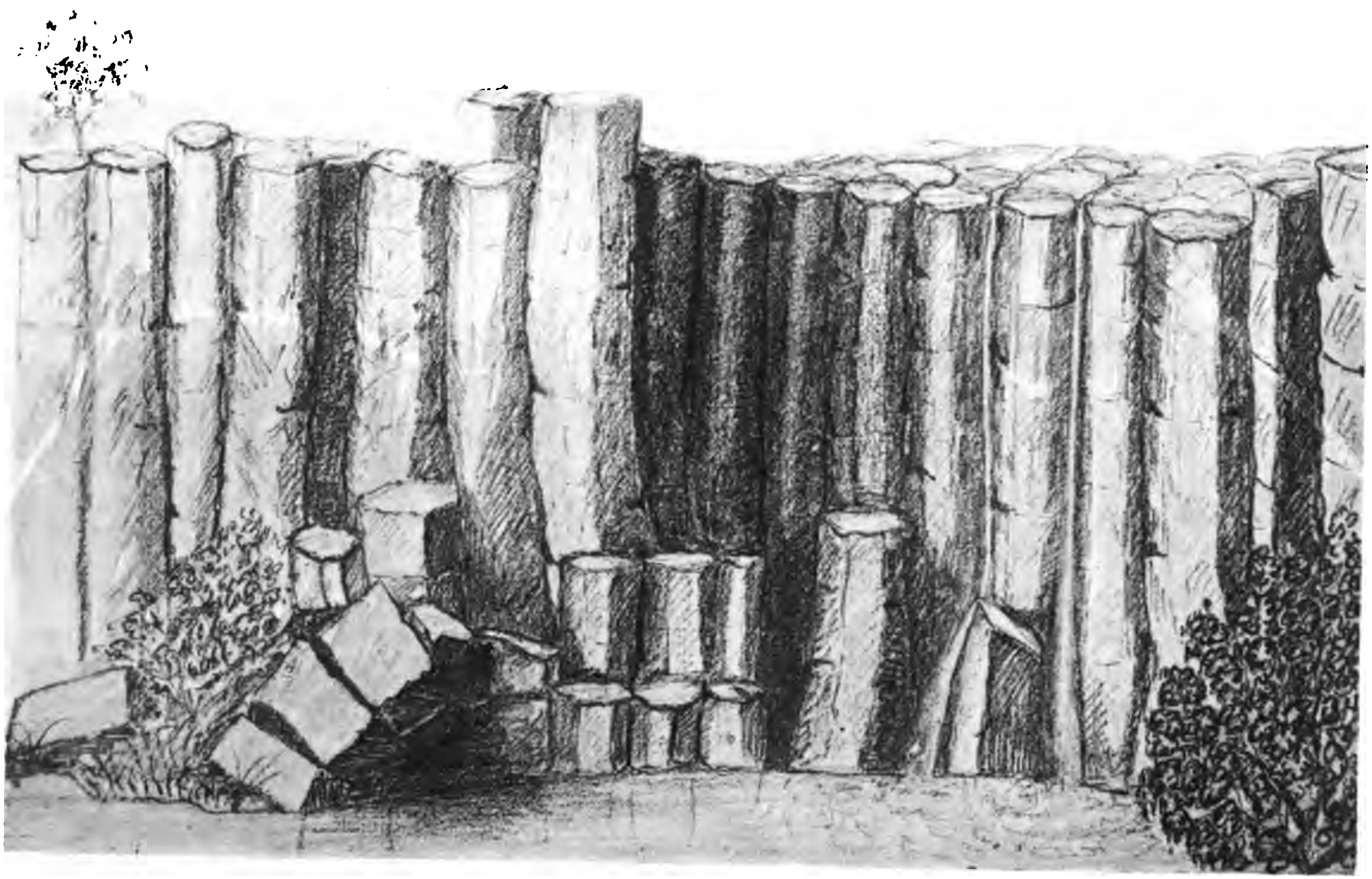


PLATE V.

Lepidodendron Volkmannianum, *Sternberg?*

Fig. 1. A small specimen, with the upper leaf scars more compressed than those towards the base.

Fig. 1*a*. Two leaf scars, somewhat enlarged.

Fig. 2. A leaf scar, somewhat enlarged, taken from a second specimen, in which the compression is still less.

Fig. 2*a*. Another leaf scar, taken from the same example, in which the outline approaches more to that of Fig. 3.

Fig. 3. Two leaf scars of the species proper for comparison with Figs. 1*a*, 2*a*; *a*, rounded upper margin; *b*, flat basal boundary line. (*See* Roemer, *Palaeontographica*, iii, t. 7, f. 13).

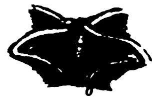
From drawings by Mr. R. Kidston.

R. K.

Fig. 1

Fig. 1a

a



b

Fig. 2

a

b

Fig. 2a

a

Z

Fig. 3

Reproduced by Heliotype.

PLATE VI.

General view of Bone Camp Gully, Portion 121, Parish of Durham, County Murchison, with the excavations made, as seen from the east side of the creek.

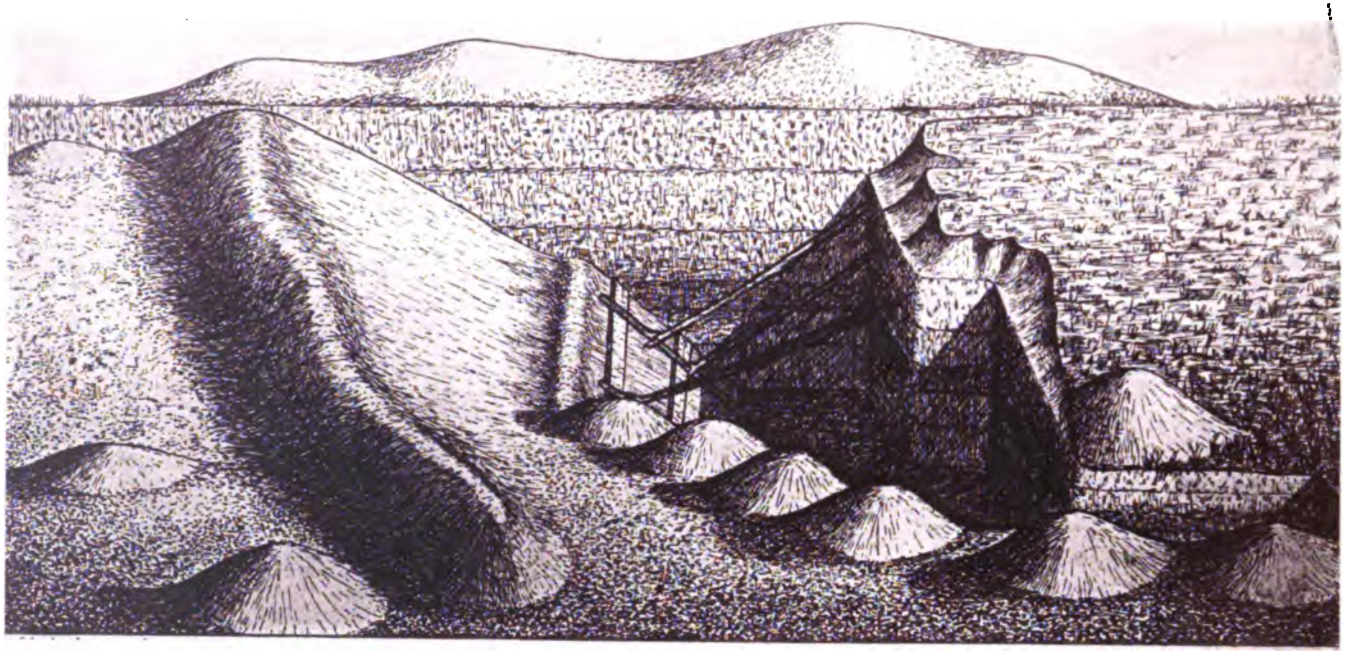
From a drawing by Mr. W. Anderson.

Reproduced by Heliotype.

PLATE VII.

General view of the excavation at Bone Camp Gully, Portion 121, Parish of Durham, County Murchison.

From a drawing by Mr. W. Anderson.



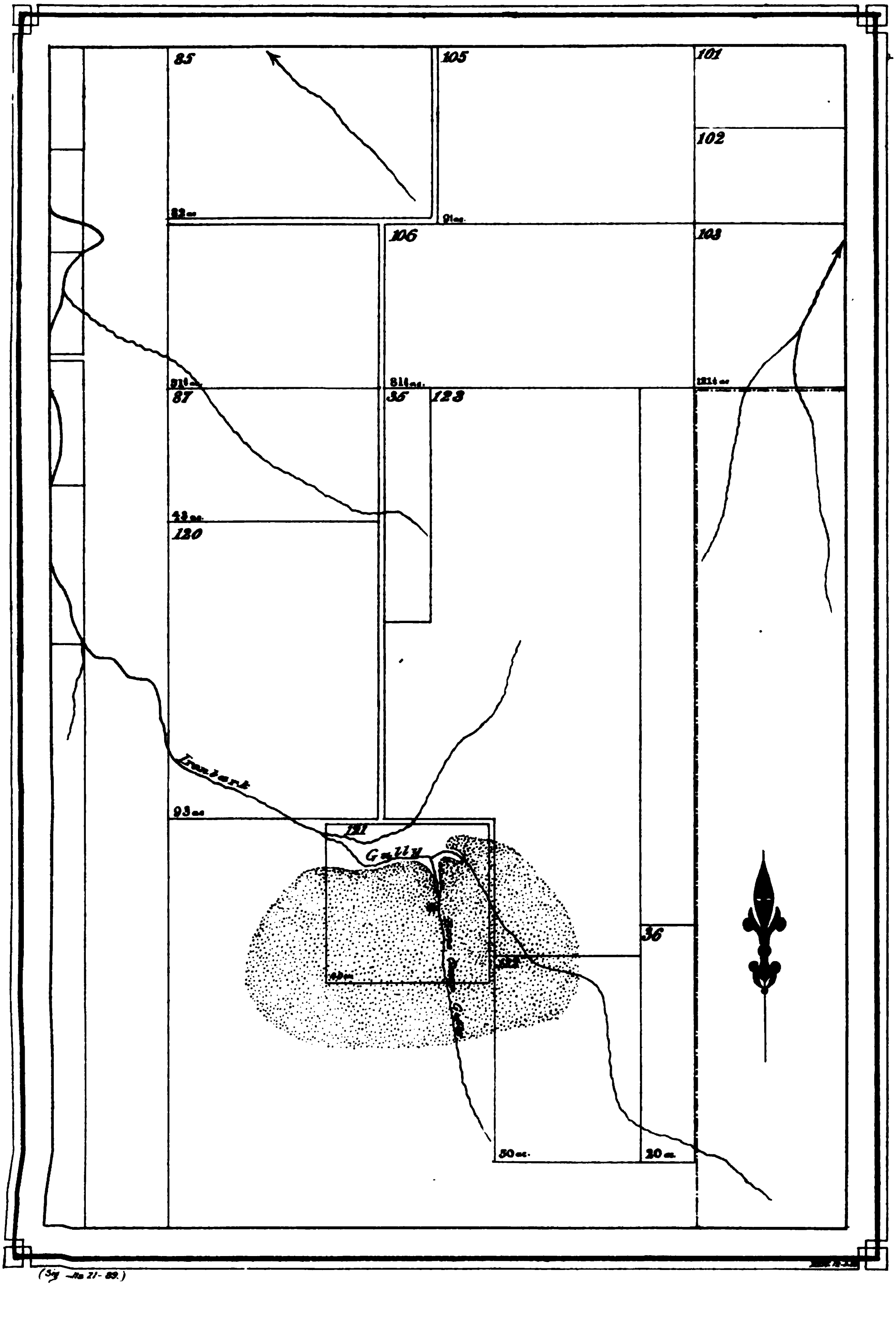
Reproduced by Heliotype.

PLATE VIII.

Plan showing the position of the Ossiferous deposit at Bone Camp Gully on Portion 121, Parish of Durham, County Murchison. Scale—eighty chains to one inch.

Extent of the deposit.

Position of the excavation.


85
105
101
102
106
103
87
35
123
120
36
Ironbark
Gully
93 ac
50 ac.
20 ac.

(Sig. 21-89.)

PLATE IX.

Plan of Portion 121, Parish of Durham, County Murchison, showing the outcrop of the bone bed, and associated deposits in Bone Camp Gully. Scale—two chains to one inch.

PLATE IX.

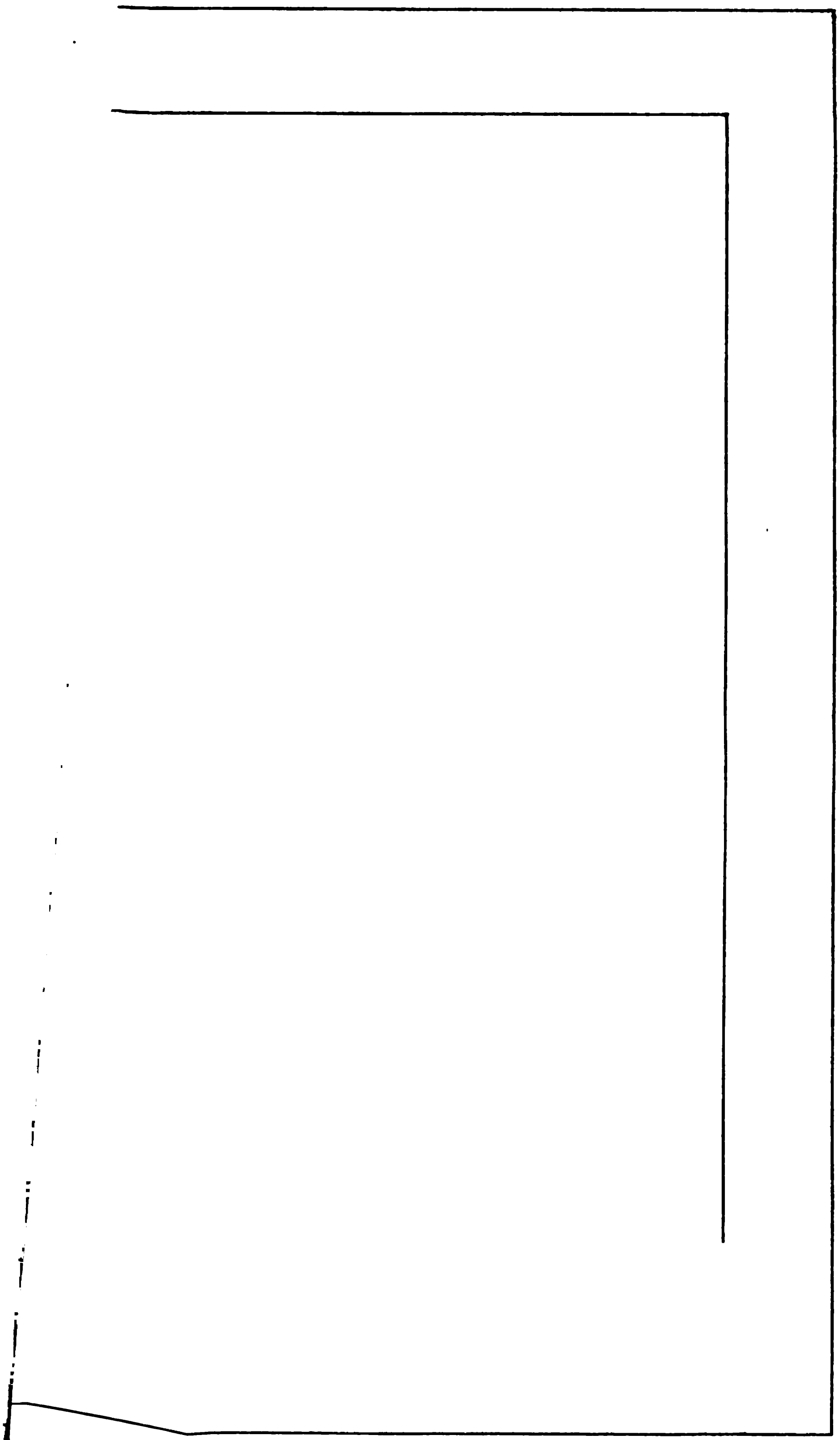
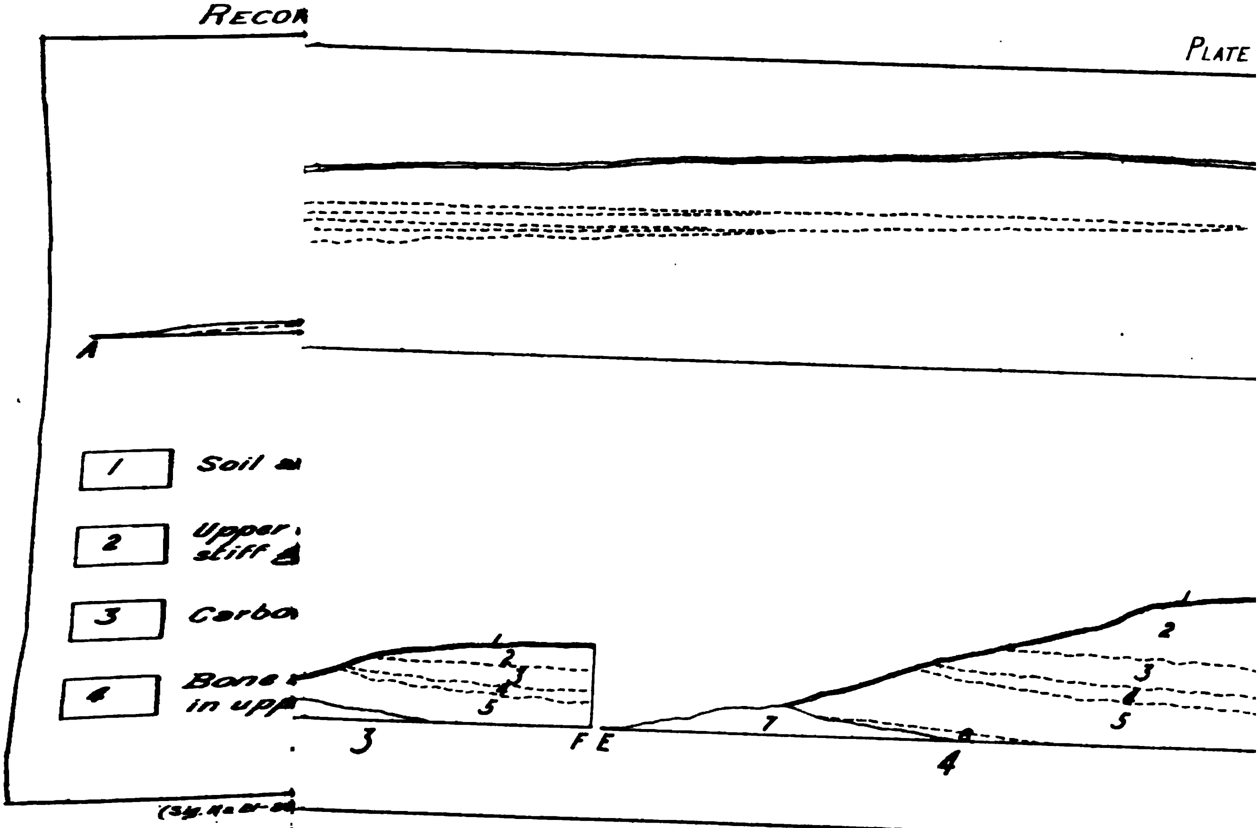


PLATE X.

Sections across the bone bed at Bone Camp Gully showing the order of sequence of the beds.

Fig. 1. North and south section, A to B, on Pl. IX.
Fig. 2. East and west section, C to D, do
Fig. 3. South-east and north-west section, E to F, on Pl. IX.
Fig. 4. East and west, and south-east and north-west section, E to G, on Pl. IX.

Scale—twenty feet to one inch, horizontal and vertical.



RECOR
PLATE
A
1 Soil a
2 Upper
stiff
3 Carbo
4 Bone
in upp
3
F E
4
7

PLATE XI.

Dromornis australis, *Owen*.

Fig. 1. Distal extremity of the right tibia seen from the inside.

Fig. 2. Proximal end of the left fibula seen from the front.

Dromaius novæ-hollandiæ, *Latham*.

Fig. 3. Distal extremity of the right tibia to show relative proportions as compared with Fig. 4.

Dromaius patricius, *de Vis*.

Fig. 4. Distal extremity of the right tibia to show the large central canal.

The figures, from photographs by Mr. H. Barnes, of the Australian Museum, are slightly reduced.


4
3
2
1

PLATE XII.

Dromornis australis, *Owen.*

Fig. 1. Distal extremity of the right tibia, seen from the posterior.

Fig. 2. Proximal end of the left fibula, seen from the exterior or outside.

Dromaius patricius, *de Vis.*

Fig. 3. Distal extremity of the right tibia, seen from the posterior.

The figures, from photographs by Mr. H. Barnes, of the Australian Museum, are slightly reduced.

11*a* 21—89

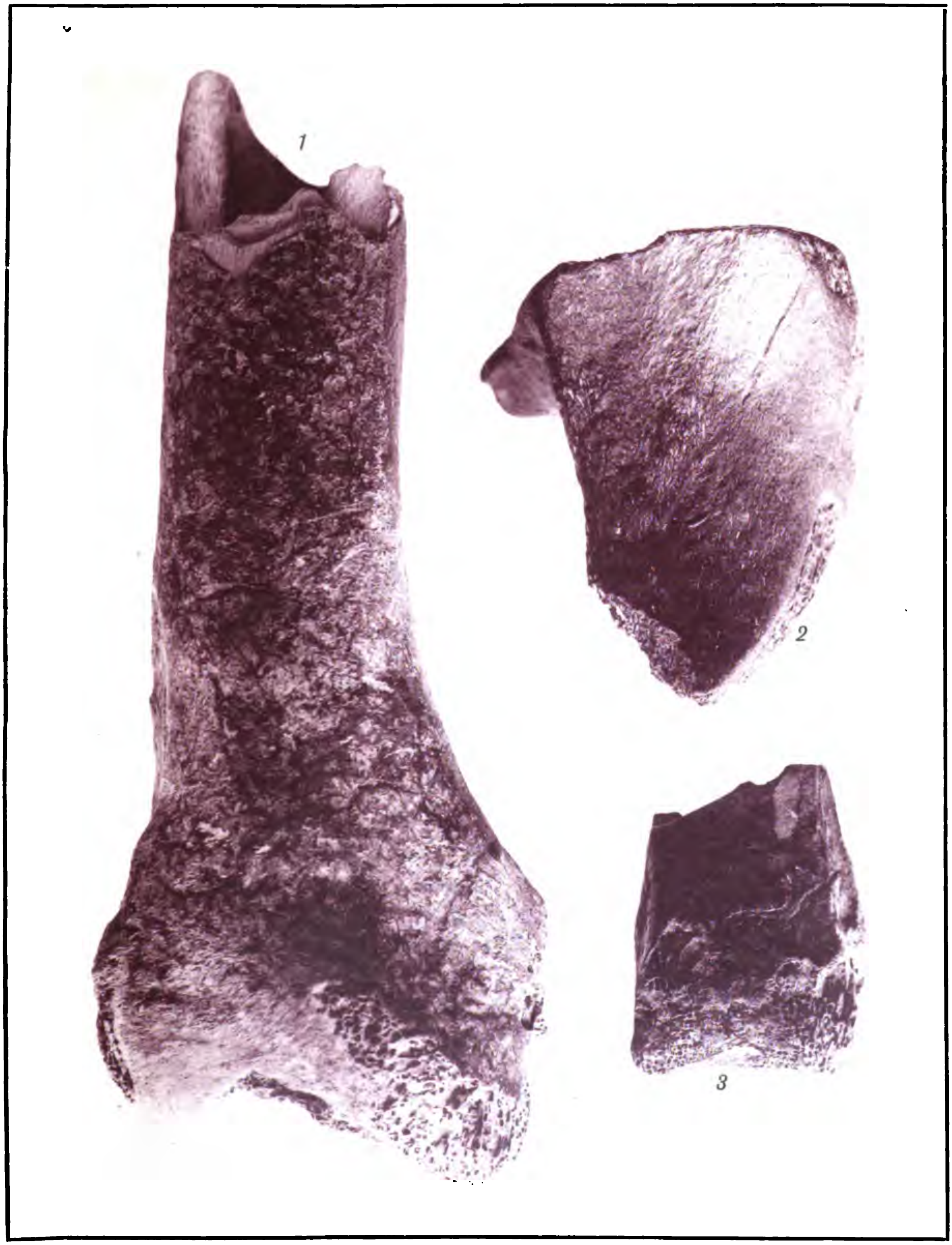

1
2
3

PLATE XIII.

Dromornis australis, *Owen.*

Fig. 1. Distal extremity of the right tibia, seen from the anterior.

Fig. 2. Proximal end of the left fibula, seen from the inside.

Dromaius patricius, *de Vis.*

Fig. 3. Distal extremity of the right tibia, seen from the anterior.

The figures, from photographs by Mr. H. Barnes, of the Australian Museum, are slightly reduced.

11*a* 21- 89

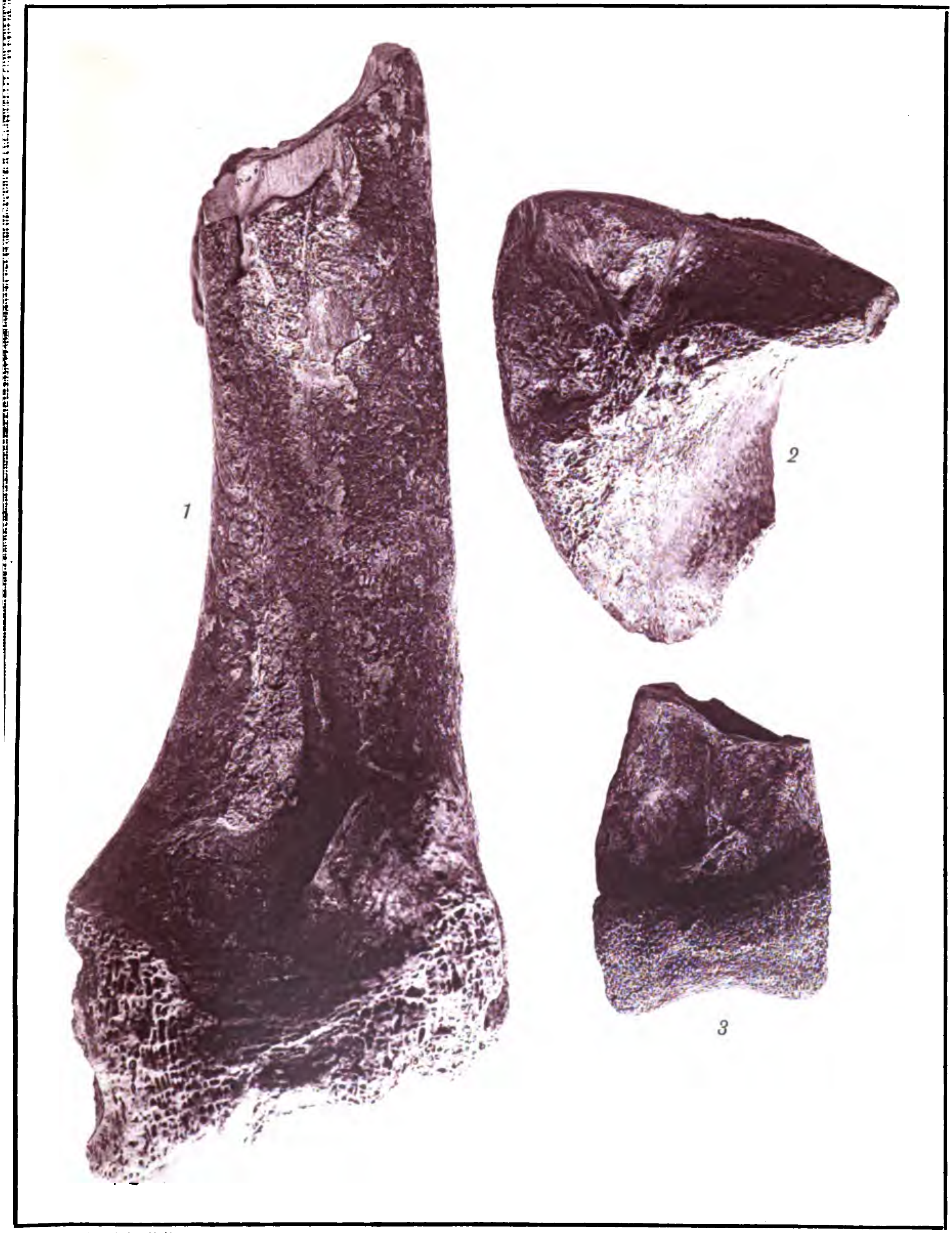


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PLATE XIV.

Plan showing the position and approximate extent, so far as traced, of the Fish and Plant-bearing bed on Boyce's Selection and its contiguity to the Talbragar River, in the north-west corne of the Parish of Bligh, County Bligh. Scale—two inches to one mile.

11*a* 21—89

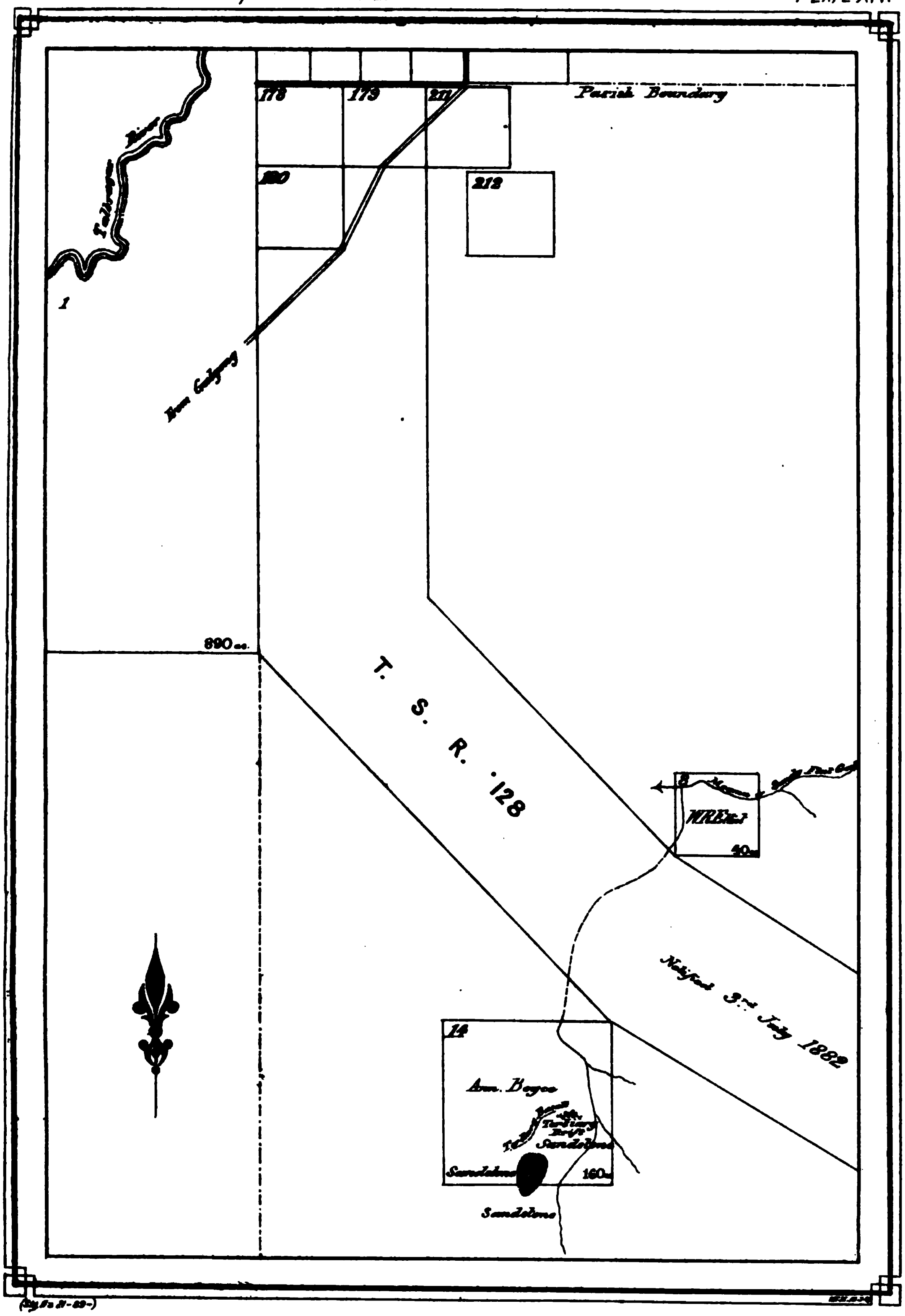
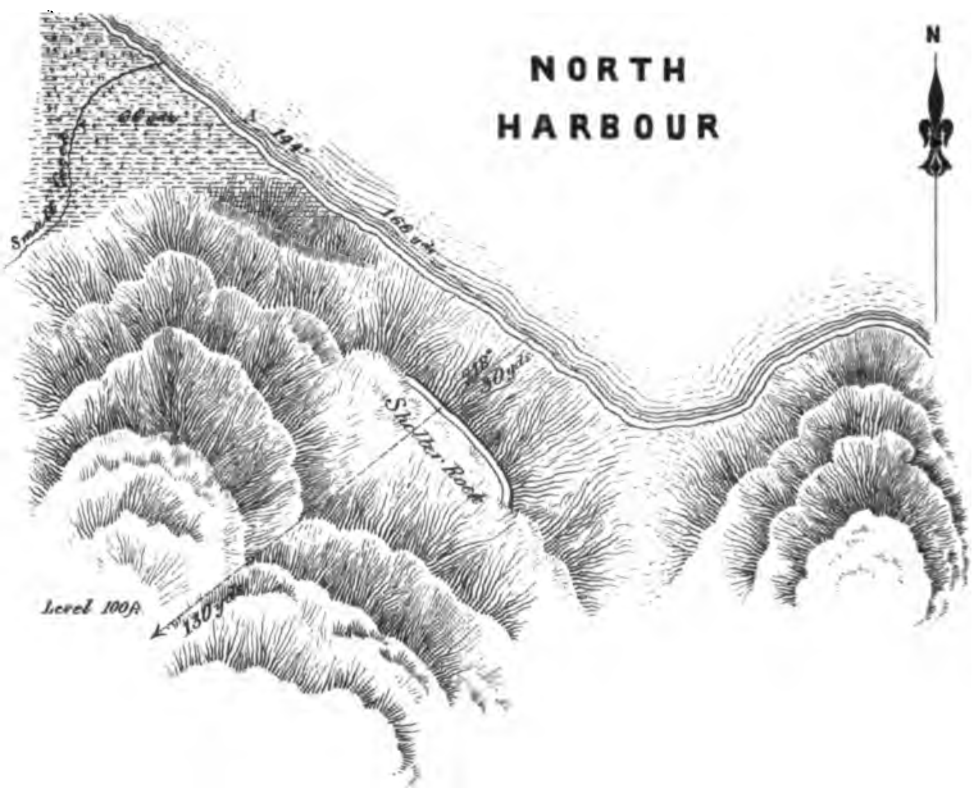

Parish Boundary
178
179
211
180
212
1
890 ac.
T. S. R. 128
Notified 3rd July 1882
40 ac.
14
160 ac.
Sandstone
Tertiary Drift
Sandstone

PLATE XV.

Sketch-plan of Forty Baskets Bay, North Harbour, Port Jackson, showing the relative position of the Shelter-rock and Kitchen-midden (A).

11a 21—89


NORTH
HARBOUR
N
Shelter Rock
Level 100ft
130 yds
168 yds
194'
60 yds

(Sig. IIa 21-89.)

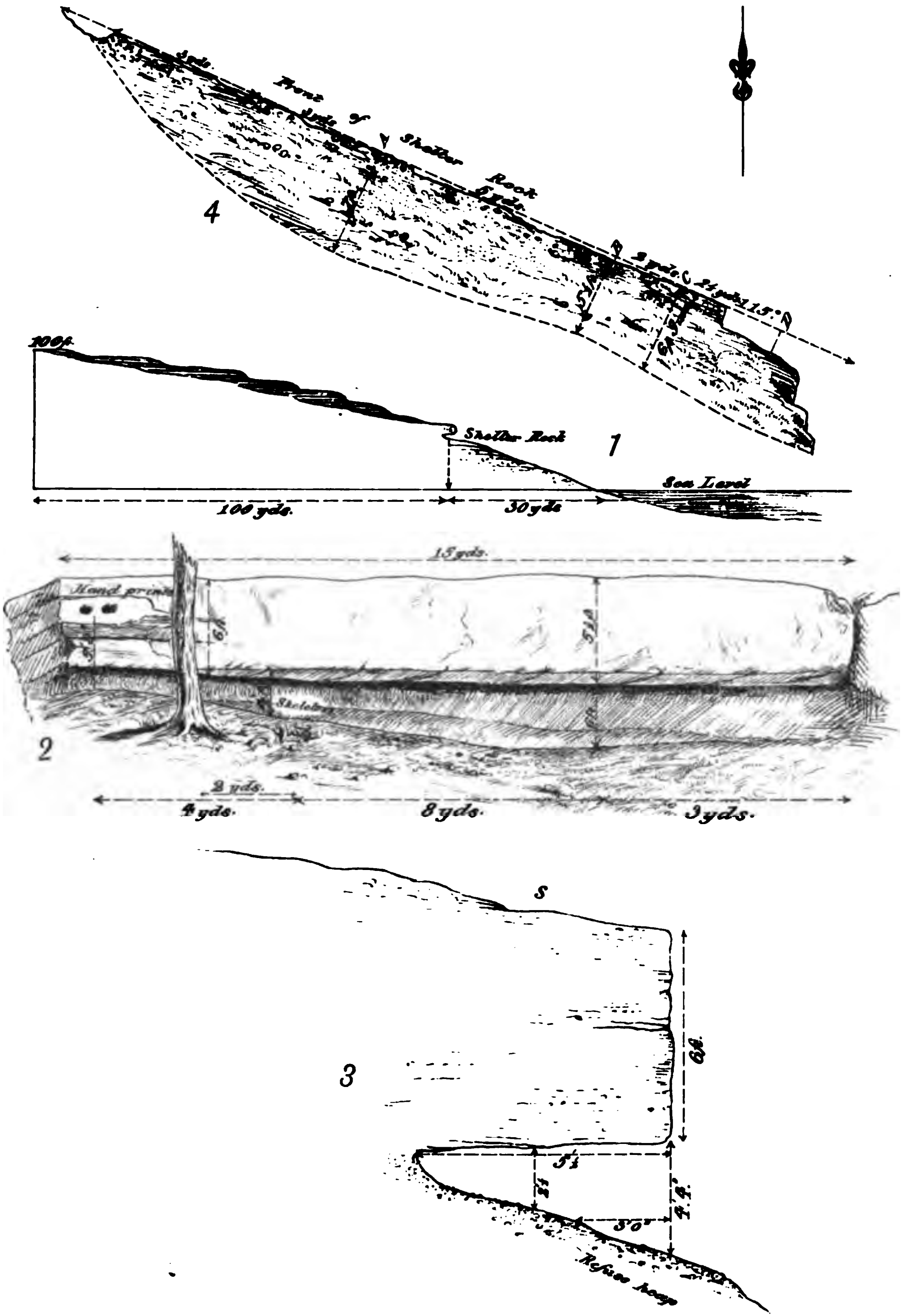
PLATE XVI.

Fig. 1. Generalized section of the shore at Forty Baskets Bay, up to the one hundred-foot level, showing the position of the Shelter-rock.

Fig. 2. Front view of the Shelter-rock, showing the relative positions of the skeletons, trunk of the *Acacia*, the hand outlines on the left, and the ash deposit or refuse heap in the foreground.

Fig. 3. Section of the same, taken across the point at which the skeletons were found.

Fig. 4. Ground plan of the Shelter.


4
Front
Shelter Rock
1
100ft.
Shelter Rock
Sea Level
100 yds.
30 yds.
15 yds.
Hand prints
2
4 yds.
8 yds.
3 yds.
2 yds.
3
6 ft.
Refuse heap

(Sig. 11a 21-83.)

PLATE XVII.

View of the Rock-shelter at Forty Baskets Bay, North Harbour, looking slightly from above and the north-east. The trunk of the *Acacia longifolia*, the roots of which were distributed throughout the skeletons, is seen in the centre of the view.

From a photograph by Mr. T. W. E. David.

Reproduced by Heliotype

PLATE XVIII.

View looking into the Rock-shelter from the north-west, or nearly along its line of frontage. The position of the *Acacia longifolia* marks the south-eastern limit of the shelter.

From a photograph by Mr. T. W. E. David.

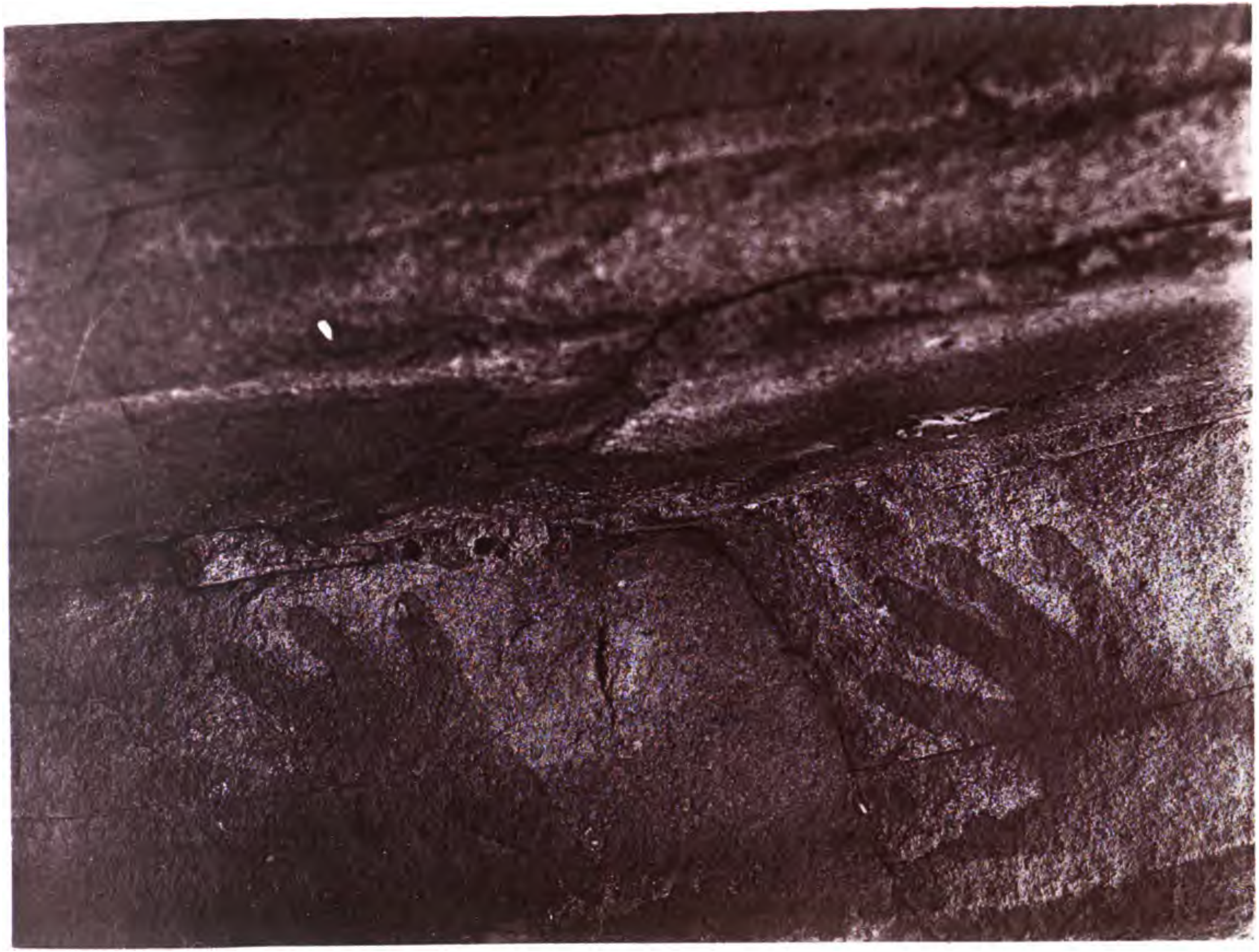
11a 21—89

Reproduced by Heliotype.

PLATE XIX.

Surface of the Hawkesbury Sandstone at the south-east end of the shelter, with one of the open hand outlines *in situ*.

From a photograph by Mr. T. W. E. David.



Reproduced by Heliotype.

PLATE XX.

Fig. 1. Distal end of a femur from the Rock-shelter, showing the tooth-marks along the anterior crest.

Fig. 2. Small implement of quartzite from the Rock-shelter, found under the skeleton of a man. The rock of which this is formed is unknown in the vicinity of North Harbour. It is probably either a skinning knife, or may have been used in the rite of circumcision.

Fig. 2*a*. A similar implement found in a like position in the Kitchen-midden burial.

Fig. 3. Pointed implement found with the man's skeleton in the Kitchen-midden. It is composed of a micaceous sandstone.

Fig. 4. Broken and roughly-fashioned implement of hornblendic quartz-porphyry, found with another man's skeleton in the Kitchen-midden, by Mr. J. Davison.

The figures are all of the natural size.

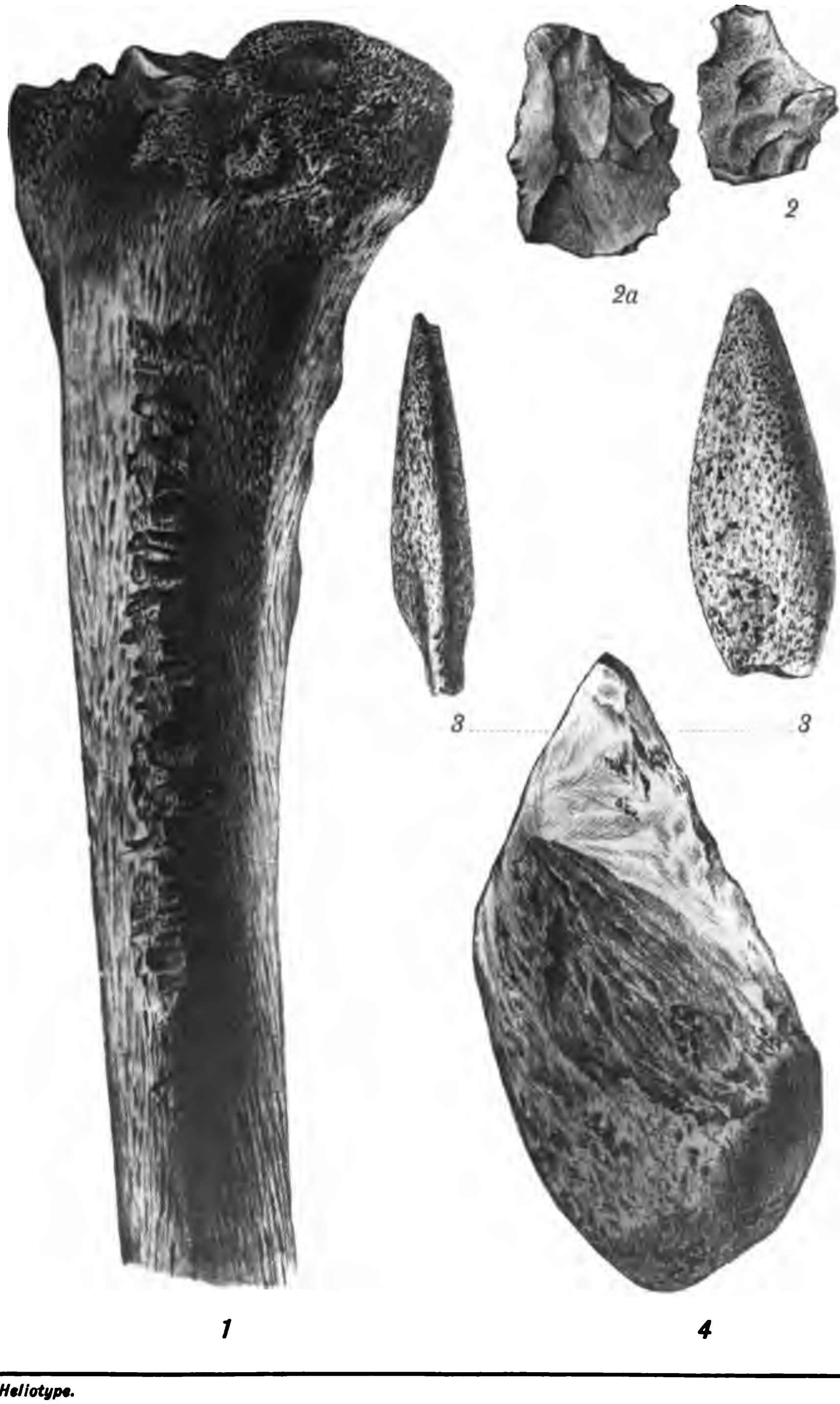


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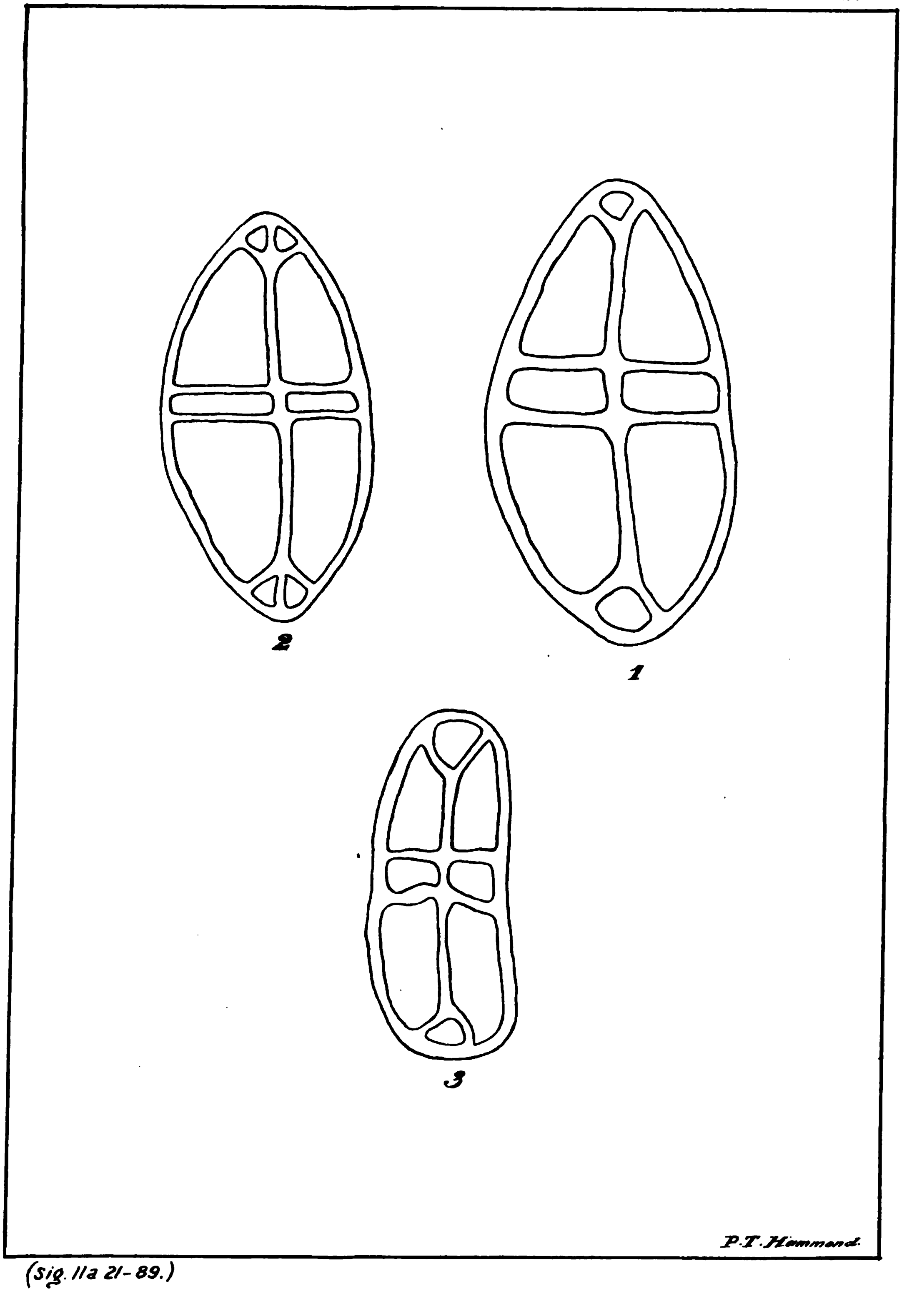
PLATE XXI.

Aboriginal Carvings exposed on the weatherd surfaces of the Hawkesbury Sandstone, near Forty Baskets Bay, overlooking the entrance to North Harbour. Scale—$\frac{1}{18}$ nat.



(Sig. 11a 21-89.)

PLATE XXII.

Skull of male Aboriginal, found reposing on the left side in the Kitchen-midden grave at Forty Baskets Bay, with the left hand pressed against the cheek and partly thrust into the orbit. Scale—½ nat.

Reproduced by Heliotype.

PLATE XXIII.

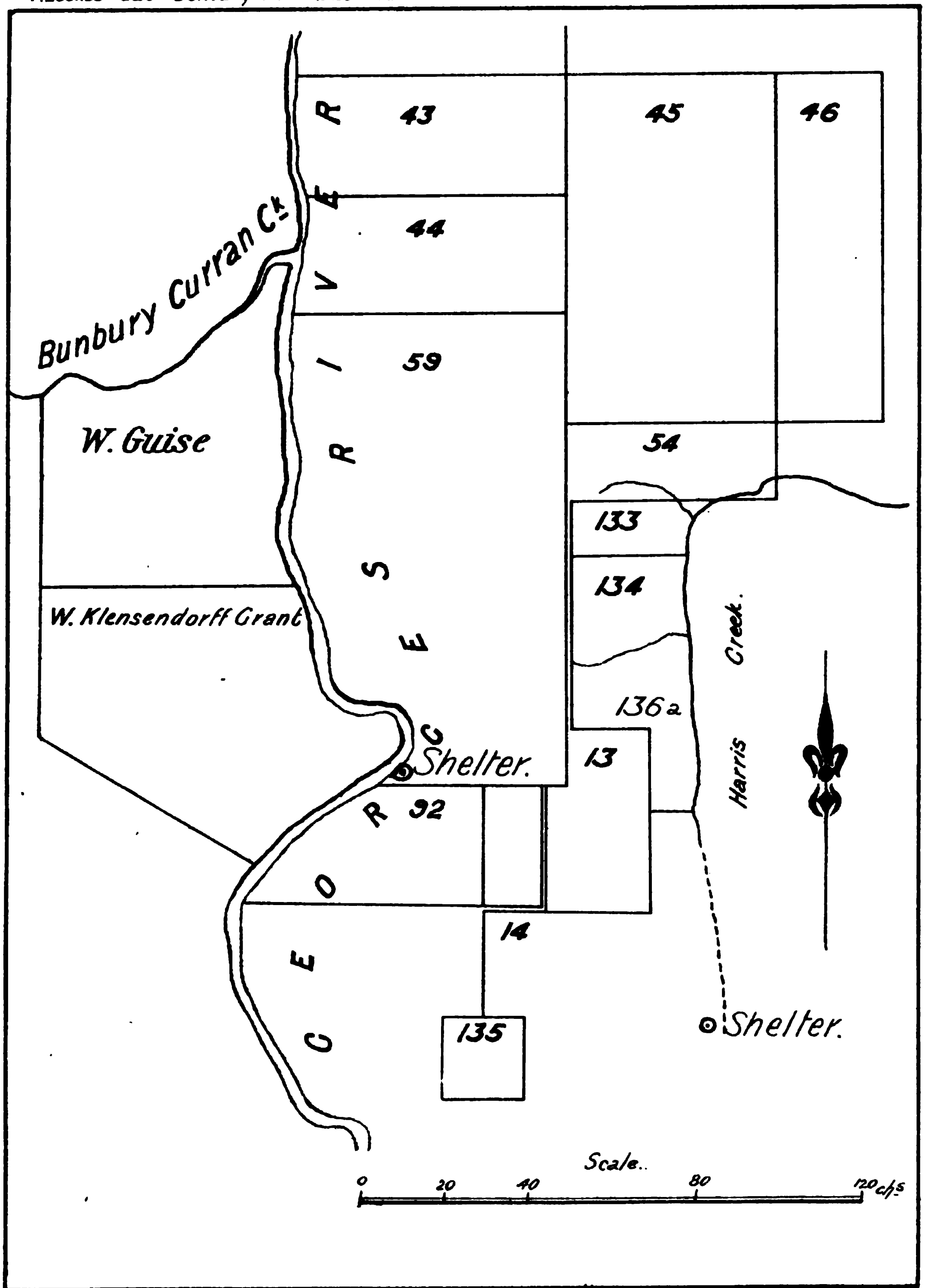
Cycadopteris scolopendrina, ***Ratte.***

Wianamatta Shales—Alexandria.

Reproduced by Heliotype.

PLATE XXIV.

Plan showing the approximate position of Rock-shelters on George's River, and Harris' Creek, Parishes of Minto and Bankstown, County Cumberland, Scale—forty chains to one inch.



GEORGES RIVER
Bunbury Curran Ck.
W. Guise
W. Klensendorff Grant
43
44
45
46
59
54
133
134
136a
13
32
14
135
Shelter.
Harris Creek.
Shelter.
Scale..
0
20
40
80
120 chs

(Sig. 11a 21-89.)

PLATE XXV.

Meiolania platyceps, *Owen.*

Fig. 1. Ventral view of a tail sheath from Lord Howe Island, showing caudal vertebræ *in situ.*

Fig. 2. Portion of an annular ring of the tail sheath; Canadian Lead.

Fig. 3. Ventral view of a caudal vertebra; Canadian Lead.

The figures, from photographs by Mr. H. Barnes, of the Australian Museum, are of the natural size.


2
1
3

PLATE XXVI.

Meiolania platyceps, *Owen.*

Fig. 1. Side view of a tail sheath from Lord Howe Island.

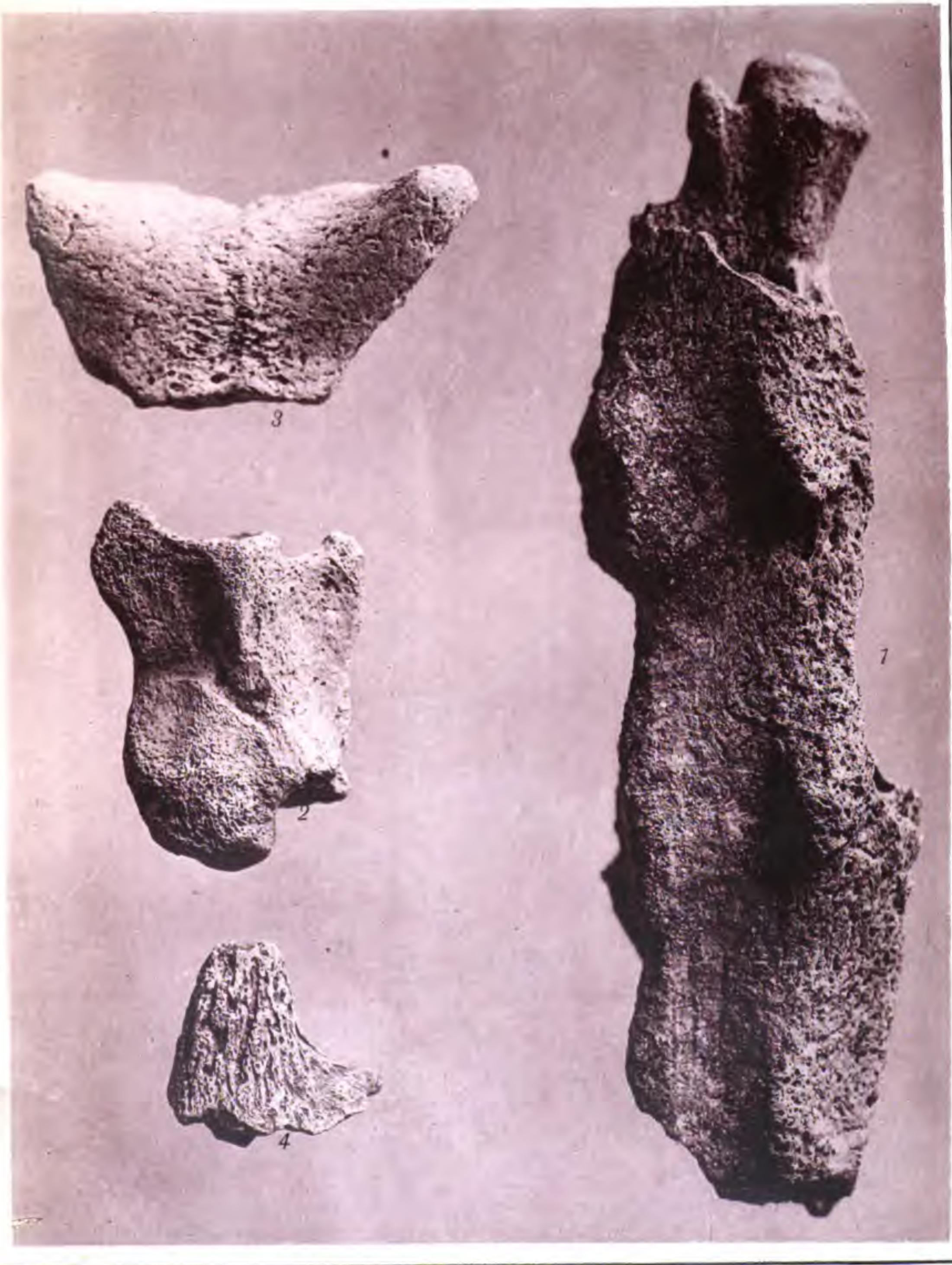
Fig. 2. Portion of another annular ring from a tail sheath, seen from above; Canadian Lead.

Fig. 3. Side view of caudal vertebra; Canadian Lead.

Fig. 4. Small horn-core seen from the side; Canadian Lead.

The figures from photographs by Mr. H. Barnes, of the Australian Museum, are of the natural size.

11*a* 227—89



Reproduced by Heliotype.

PLATE XXVII.

Fig. 1. Map of New South Wales showing positions of occurrence of Leucite basalt

Fig. 2. Geological sketch map of vicinity of Byrock.

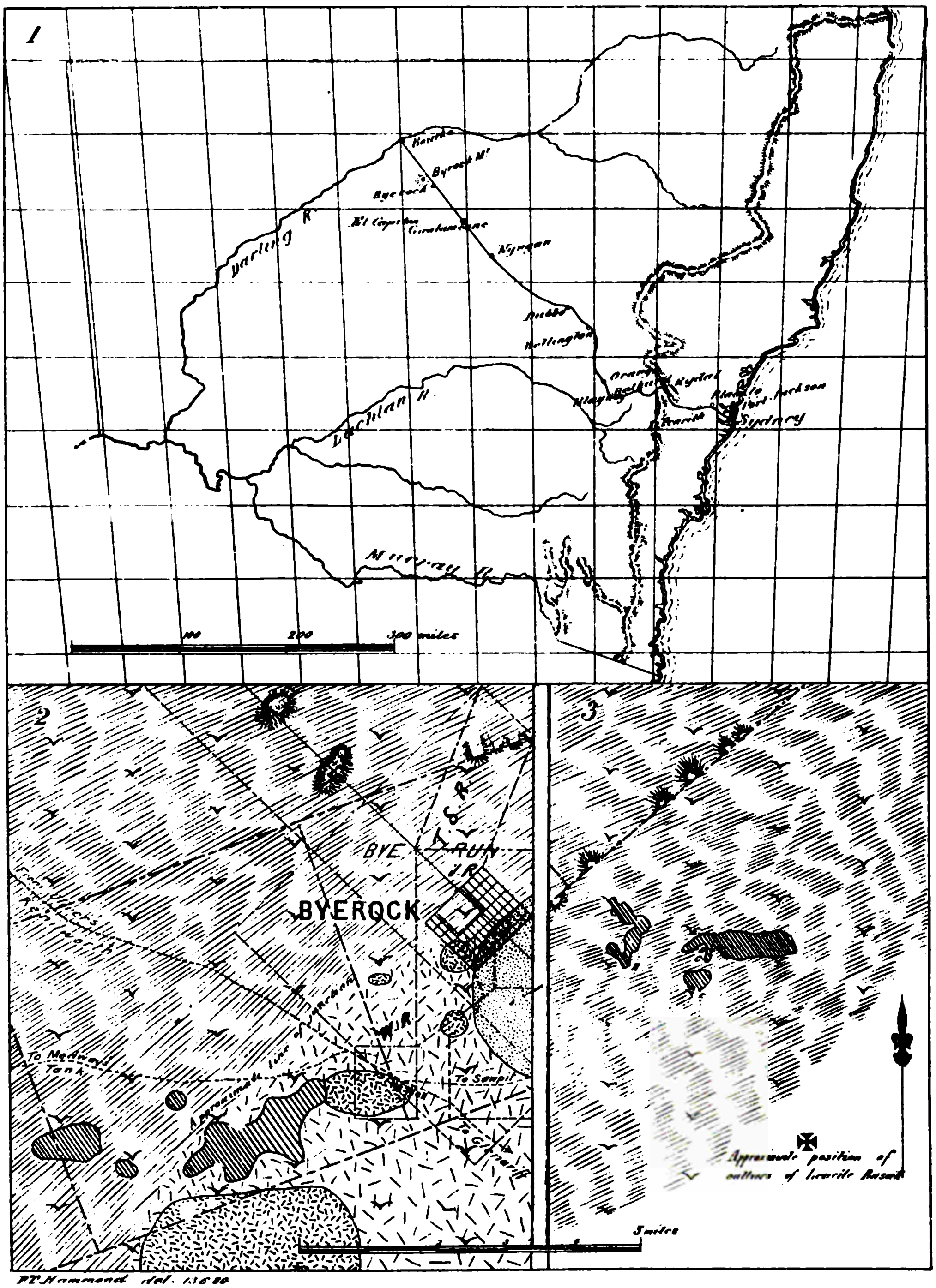
Fig. 3. Geological sketch map of vicinity of El Capitan.

Index of geological signs used in Figs. 2 and 3.

Granite. Silurian. Cretaceous

Leucite Basalt. Pleistocene red soil.

Maps drawn by P. T. Hammond.



P.T. Hammond del. 13.6.90
(IIa 227-89.)

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE, SYDNEY, NEW SOUTH WALES.

PLATE XXVIII.

Fig. 1. Showing brecciated character of rock at El Capitan (Slide No. 63*c*).

Fig. 2. Leucite crystals. Showing circular arrangement of glassy inclusions (Slide No. 58); showing branching tubuli (Slide No. 50*a*); showing zonal growth lines (Slide No. 58).

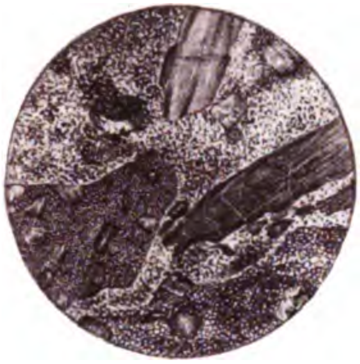
Fig. 3. Olivine crystals showing incipient horizontal lines of decomposition in its early stage (Slide No. 59*b*).

Fig. 4. Showing circular arrangement of leucite crystals around a nucleus of magnetite and mica (Slide No. 58).

Fig. 5. Three crystals of decomposing Olivine. One showing geniculate twinning (Slide No. 52*a*).

Fig. 6. Showing general microscopical structure of typical leucite basalt from Byrock Mountain (Slide No. 52*a*).

All the figures drawn from sections by P. T. Hammond.



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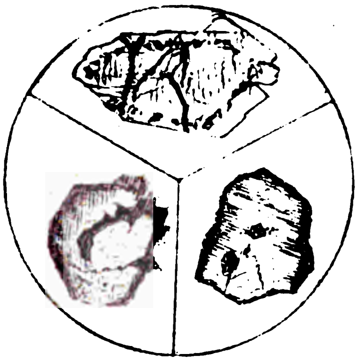

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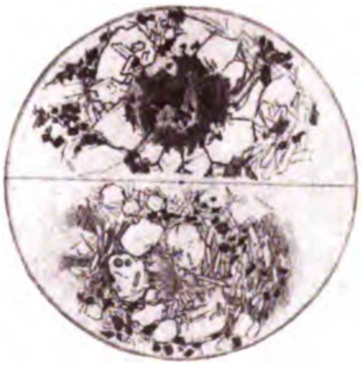

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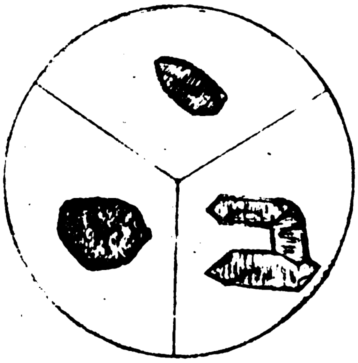

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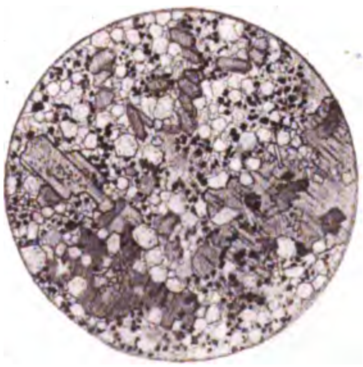

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Reproduced by Heliotype. *11a 227—89*

PLATE XXIX.

Fig. 1. *Stephanoceras*, allied to *S. lamellosus*, J. de C. Sowerby ; Strickland River.

Fig. 2. *Stephanoceras*, allied to *S. Blagdeni*, J. Sowerby ; Strickland River.

Fig. 3. *Stephanoceras*, allied to *S. lamellosus*, J. de C. Sowerby ; Strickland River.

Fig. 4. An Ammonite, allied to *Ammonites lingulatus*, Quenstedt, *teste* H. Woodward ; Strickland River.

Fig. 5. *Stephanoceras*, allied to *S. calloviensis*, Sowerby ; Strickland River

The figures from photographs by Mr. H. Barnes, of the Australian Museum, are reduced nearly one-third

PLATE XXX.

Geological sketch map of the neighbourhood of the Soda Spring, with plan of part of survey in township of Rock Flat.

Tertiary basalt.	Calcareous tufa.
Siluro-Devonian quartzite.	Pleistocene alluvia.

Map drawn by P. T. Hammond.

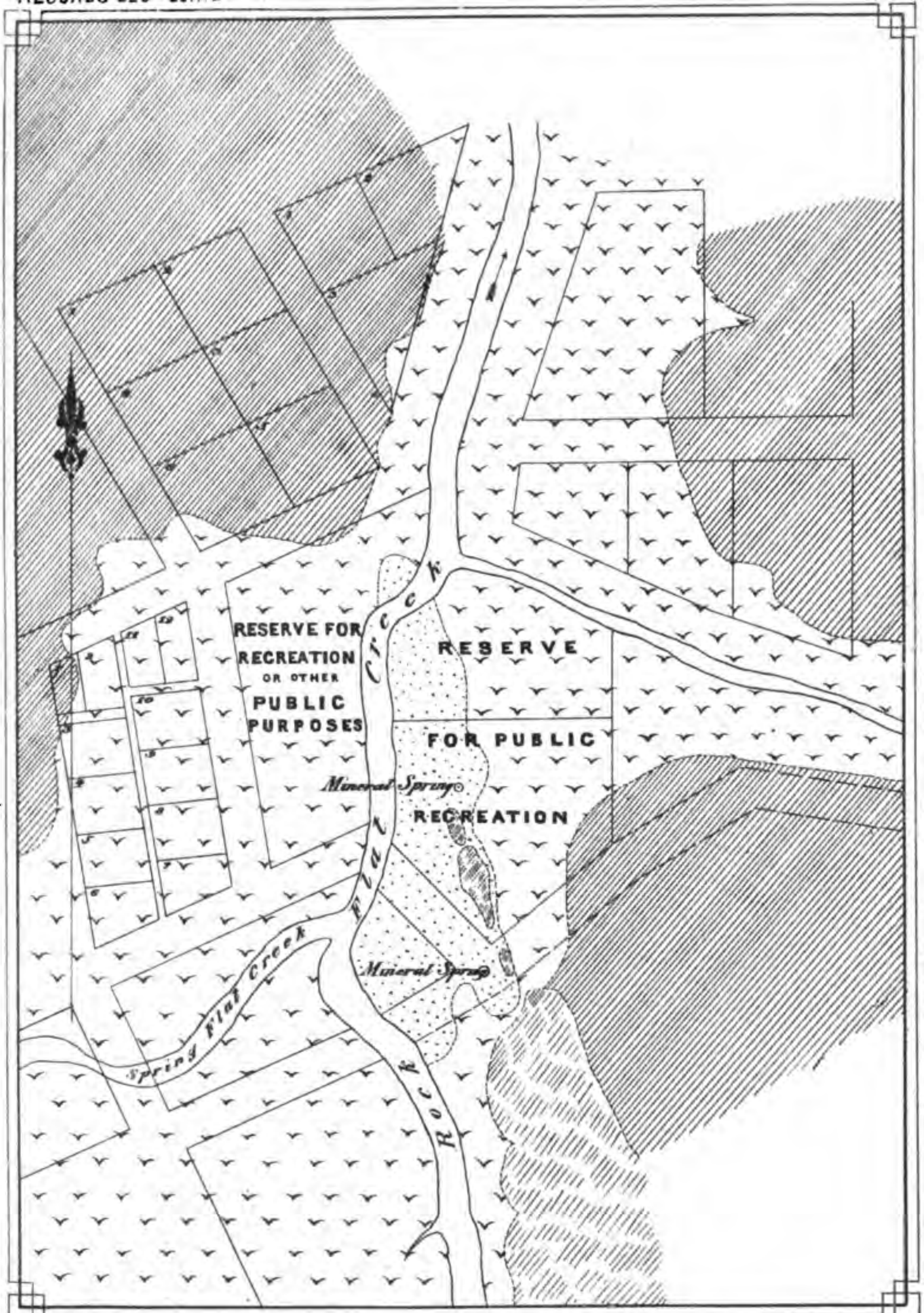

PHOTO-LITHOGRAPHED AT THE GOVT. PRINTING OFFICE,
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Aug. 10, 1889.

DEPARTMENT OF MINES, SYDNEY.

RECORDS

OF THE

GEOLOGICAL SURVEY OF NEW SOUTH WALES.

VOL. I, PART I.

1889.

CONTENTS.

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11a 234-88 1889.

[*Price*, 1*s*. 6*d*.]

GEOLOGICAL MAPS AND PUBLICATIONS ISSUED BY THE DEPARTMENT OF MINES, SYDNEY.

(1.) MAPS.

Map showing Mineral Areas of New South Wales. Scale, 8 miles to 1 inch.
Do do do Scale, 50 miles to 1 inch.
Geological Sketch Map of New South Wales, compiled from the Maps of the late Rev. W. B. Clarke, M.A., F.R.S., by C. S. Wilkinson, L.S., F.G.S., Government Geological Surveyor-in-charge. Scale, 8 miles to 1 inch.
Do do do do Scale, 22 miles to 1 inch.
Geological Map of the Districts of Hartley, Bowenfells, Wallerawang, and Rydal, by C. S. Wilkinson, L.S., F.G.S.
Geological Map of Hill End and Tambaroora, by E. F. Pittman, Geological Surveyor.
Geological Map of the Vegetable Creek Tin-mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor. Scale, 58 chains to 1 inch.
Index Map of the Vegetable Creek Tin-fields, by T. W. E. David, B.A., F.G.S. Scale, 80 chains to 1 inch.
Geological Map of the Forest Reefs District, by H. Y. L. Brown, Geological Surveyor.
Map of the Silver-mining Country, Barrier Ranges, by C. S. Wilkinson, L.S., F.G.S.
Vertical Sections of New South Wales Upper Coal Measures, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Diagrams showing the Thickness, Character, and Portion mined out of Coal-seams in the Coal Measures of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal-fields.
Plans showing the Outcrop, Thickness, and Dip of the Coal-seams in the Northern, Southern, and Western Coal-mining Districts of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal-fields.

(2.) PUBLICATIONS.

The Mining Act of 1884, with Regulations.
Annual Reports from 1875 to 1887 inclusive.
Mines and Mineral Statistics, 1875.

MINERAL PRODUCTS OF NEW SOUTH WALES, 1882, containing :—

1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
2. Notes on the Geology of New South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
3. Description of the Minerals of New South Wales, by Archibald Liversidge, M.A., F.R.S., F.C.S., F.G.S., &c., Professor of Chemistry and Mineralogy in the University of Sydney.
4. Catalogue of Works, Papers, Reports, and Maps on the Geology, Palæontology, Mineralogy, &c., &c., of the Australian Continent and Tasmania, by Robert Etheridge, Junr., of the British Museum, and Robert Logan Jack, F.R.G.S., F.G.S., Government Geologist for Queensland.

MINERAL PRODUCTS OF NEW SOUTH WALES, 2nd Edition, 1886, containing :—

1. Mineral Products of New South Wales, by Harrie Wood, J.P., Under Secretary for Mines.
2. Notes on the Geology of New South Wales, by C. S. Wilkinson, L.S., F.G.S., Geological Surveyor-in-Charge.
3. The Collieries and Boghead Mineral Mines of New South Wales, by John Mackenzie, F.G.S., Examiner of Coal Fields.

MEMOIRS OF THE GEOLOGICAL SURVEY OF NEW SOUTH WALES.

Geology.

1. Report on the Vegetable Creek Tin Mining District, by T. W. E. David, B.A., F.G.S., Geological Surveyor.

Palæontology.

1. The Invertebrate Fauna of the Hawkesbury-Wianamatta Series of New South Wales, by Robert Etheridge, Junr., Palæontologist to the Geological Survey of New South Wales ; and Australian Museum, Sydney. (4to. Sydney, 1888.)
2. Contributions to the Tertiary Flora of Australia, by Dr. Constantin, Baron von Ettingshausen, Prof. of Botany, University of Graz, Austria. (4to. Sydney, 1888.)

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